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UNITED STATES DEPARTMENT OF AGRICULTURE
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RECONNAISSANCE EROSION SURVEY OF THE BRAZOS RIVER WATERSHED TEXAS

By

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By H. V. Geib, *scientist in soil erosion, Soil Investigations, Bureau of Chemistry and Soils,* and Ira T. Goddard, *assistant agronomist in soil conservation, Oklahoma Agricultural Experiment Station*

The Bureau of Chemistry and Soils, in Cooperation with the Texas Agricultural Experiment Station

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INTRODUCTION

For years it has been realized that erosion is taking excessive toll of the farming lands of Texas. Light-colored areas appearing in cultivated fields have given indication that the surface soil is being rapidly washed away by sheet erosion, leaving the less productive subsoil exposed. Extensive gullying has taken place, making it more and more difficult to farm the land thus affected. Thousands of acres of formerly productive fields already have been abandoned. Crop yields have decreased alarmingly, and on a large total area it is no longer possible to produce satisfactory yields. Furthermore, excessive overflows of streams are occurring with increasing frequency, and highly destructive floods are becoming of common occurrence.

Realizing that not only protective, but remedial measures should be undertaken at the earliest possible moment, a small group of public-spirited citizens combined their efforts to effect some system whereby the run-off waters of the Brazos River drainage area could be controlled, thereby preventing or minimizing the damage done by erosion, and holding in control accumulations of these waters for the purpose of eliminating injurious overflows, and for economic

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use in such public projects as supplying water for communities, power plants, and for irrigation.

Accordingly, the Brazos River Conservation and Reclamation District was organized. This district includes the total area of all counties of Texas which lie wholly, or have any portion within the drainage area of the Brazos River.

Although funds for projecting a systematic development of the general plans have been almost entirely lacking, some support and encouragement has been given by several organizations in carrying on investigations of particular features connected with the general program. The principal agencies which have been more or less active at various times are property owners, State drainage and reclamation department, State legislature, Texas Agricultural Experiment Station, United States Department of Agriculture, and others.

With these agencies cooperating it was decided to make a study of the erosion situation over the entire Brazos River watershed to determine the extent to which erosion had already progressed, the kinds of soil most seriously affected, and the apparent possibilities for better control. Such a study of erosion was obviously necessary before effective measures could be taken to deal with (1) flood control, (2) the reclaiming of the large areas of fertile land now subject to frequent inundation, and (3) the development of effective impounding reservoirs to supply irrigation water to lower-lying lands.

In line with studies of the national problem of soil erosion, the United States Department of Agriculture, in cooperation with the Texas Agricultural Experiment Station, undertook to make an erosion survey of that portion of the newly formed district which is drained by the Brazos River. This area is known as the Brazos River watershed area. It was proposed to use this definite area as a specific project in determining the facts relating to the approximate extent of devastation and damage caused by erosion, more especially in reference to the actual and comparative injury suffered by the vast areas of agricultural lands, and to attempt an estimate of the losses to productive soils caused by erosion in this region. The following report presents the findings of this survey and discusses briefly the conditions existing in the different regional sections of the Brazos River watershed.

It should be borne in mind that, owing to the general nature of this survey, the data presented herewith are not absolute. They give, nevertheless, an approximate appraisal of the situation, such as should prove helpful in the development of plans and programs aimed at better protection of the area. All the calculations are based upon actual measurements taken systematically throughout the entire region, and are regarded as relatively accurate. This report should not in any way be construed as an attempt to offer this as an exceptional region where erosion has reached its climax as an agency of land impoverishment and destruction. In fact, erosion is equally harmful in numerous other regions, and has been found even more severe in various other parts of the country where erosion studies have been made.

THE SURVEY

The Brazos River rises just within eastern New Mexico and enters Texas in the northwestern part of the State. It continues in a general southeasterly direction and finally empties into the Gulf of Mexico at Freeport, Tex.

Where the river enters the State it is no more than a small "draw" which is dry except just after heavy rains. As it proceeds onward and is joined by numerous tributaries it rapidly becomes larger, until at its outlet its average discharge is nearly 8,000 cubic feet per second.[1] During periods of excessive rainfall, tremendous damage is done by the washing away of enormous quantities of soil from sloping cultivated and heavily grazed areas of the watershed, and by the inundation of fertile valley lands. The alluvial soils, which are subject to overflow, comprise some 3,000,000 acres of the richest soil in the State.[2]

This erosion survey covered the entire watershed of the Brazos River in Texas and includes all the land that drains into the Brazos River and its tributaries. Over most of the area the outlines of the watershed are quite clearly defined, but on the High Plains of west Texas the greater part of the run-off water finds its way into the numerous depressions which dot the plains, and there it remains until it is taken up by the soil, or evaporates, and but little of it finds its way into any regular watercourse. For the purpose of this survey, however, the watershed in this region includes all the land which will probably drain into the Brazos River in time to come, when the drainage system of the plains has become more nearly mature. The boundaries extend about half way to the Wichita River on the north and to the watershed of the Colorado on the south.

The total area included in this survey is a little more than 27 million acres and comprises 70 counties and parts of counties. Of this total, 9,483,807 acres are classed as crop land, 14,237,041 acres as pasture (including rough stony land and rough broken land), and 3,393,392 acres as woodland.[3]

METHODS USED IN SURVEY

The actual measurement of the various types of eroding areas was made by means of a crop meter attached to an automobile in place of the ordinary speedometer. This method of measurement has long been used by the Bureau of Agricultural Economics in obtaining estimates of the acreages of various crops grown. It was also employed by the Oklahoma Agricultural Experiment Station in making an extensive erosion survey in Oklahoma.

In making the survey of the Brazos River watershed of Texas, from 150 to 250 miles of strategic roads were driven over in each county, and the lineal distance of each type of erosion was recorded on the crop meter. The roads traveled were selected so as to cover, as equally as possible, all sections of the county. Each county was surveyed as

[1] Unpublished data (subject to correction) covering 13 years, collected by the U.S. Geological Survey in cooperation with the Texas State Board of Water Engineers. Data furnished by C. E. Ellsworth, district engineer, U.S. Geological Survey.

[2] Estimates made by B. F. Williams, State reclamation engineer; based upon surveys made in various parts of the Brazos River watershed by the State reclamation department and reported in the biennial report of the State reclamation engineer, Tex. Reclam. Dept. Bul. 22, Sept. 1932.

[3] From data obtained by this survey.

a separate unit (tables 1 and 2) and the data were assembled and combined according to the general soil and topographic divisions (table 3).

DEFINITION OF TERMS IN EROSION CLASSIFICATION

In order that there may be no misunderstanding of the text and tables of this report the principal terms used in erosion classification have been defined as follows:

Cultivated land.—All land being cropped at time of survey.

Uncultivated land.—All land not being cropped, such as permanent pasture timbered land, rough broken and rough stony land, and "cedar breaks."

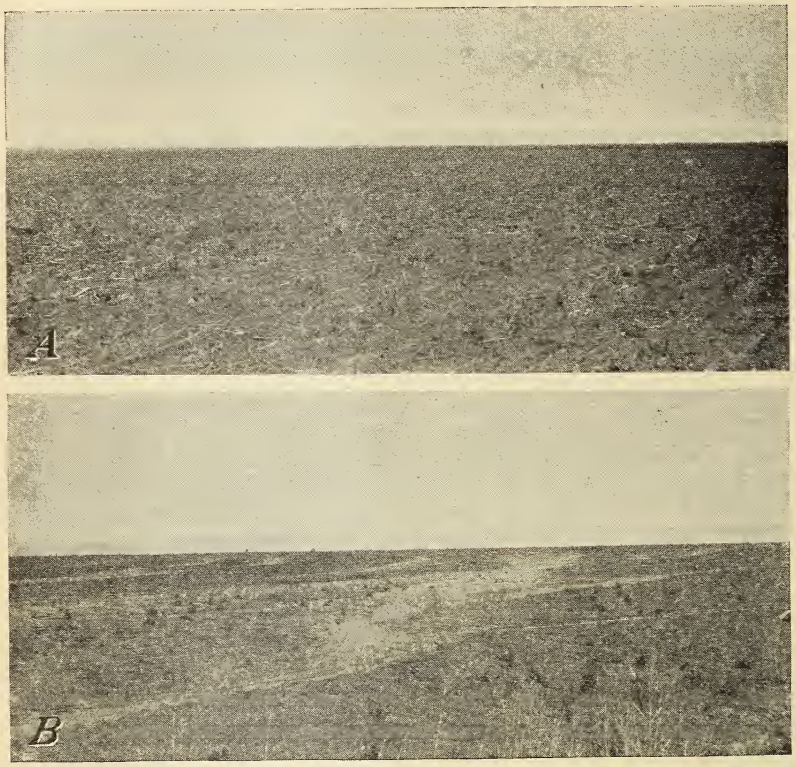

FIGURE 1.—*A*. Typical view of Amarillo clay loam in eastern Crosby County, High Plains region, classed as "level." Erosion here is comparatively slight, although during intense rains, water and soil losses are quite significant. *B*. Gullied Houston black clay, with subsoil and parent material exposed. The damage in the foreground was caused by a 2-inch rain on April 29, 1931.

No erosion—Level or nearly level cropped land, areas that appear essentially level to the eye, as that shown in figure 1, *A*. This land, in reality, is subject to considerable sheet erosion by heavy showers, and even to some gullying, especially where water runs over it from higher areas.

Sheet erosion.—Cropped land which has enough slope to be readily perceptible to the eye, and from which the surface soil is being washed more or less evenly, without much accompanying gullying, as yet. This is the most common type of erosion in the region, and the most menacing. Its progress, while in numerous places rapid, is not so noticeable as a rule as is gullying, and, therefore, is often overlooked, or ignored. Its effects are revealed by (1) light-colored spots throughout the field, representing exposures of the lighter-colored subsoil; (2) decreased crop yields; and (3) by accentuated difficulties of tillage (fig. 1, *B*).

Where such land is protected by efficient terraces, it is not included in this classification, being designated "terraced land", instead.

Slightly gullied.—This class of eroding land includes all cultivated land in which small gullies have formed, that is, washes too small, generally, to interfere seriously with cultivation. It is obvious that all such land is suffering also from sheet erosion taking place between the gullies, since such land usually is more sloping or the soil is more erosive than where no gullying has taken place.

Badly gullied.—Cultivated land which is too severely gullied to be included under the designation slightly gullied. The gullies here are so numerous, or so deep, or both, as to interfere very seriously with cultivation. As a rule, wheel implements or harvesting machinery cannot cross such gullies.

Abandoned due to gullying.—This classification includes all land that was once cultivated, but on which cropping has been abandoned owing to extreme gullying.

There are many thousands of acres which have been abandoned because of decreased yields resulting largely from sheet erosion. Such areas usually support a mixed growth of weeds and grasses and afford some pasturage. These were not classed as "abandoned" but were included with "pasture land", since time was not available to make a study of each pasture to determine whether or not it had once been cropped and, if so, the cause for abandonment.

Terraced.—All land efficiently terraced, that is, having terraces which are operating effectively. This does not include land that is only contoured, or land that was once terraced but on which the terraces are not being maintained.

Pasture land, not gullied.—Permanent pasture land which has not suffered materially from gullying. Where pasture land is sloping or rolling, some sheet erosion is taking place. This is especially true where the land is pastured too closely. The losses from sheet erosion, however, even on overgrazed land, are not nearly so great as on cultivated land. The pasture lands, especially in west Texas, often support a scattering growth of mesquite trees and various bushes and shrubs, and, farther east, some scrubby oak, sumac, and other plants. These usually are not numerous enough, however, to interfere seriously with pasturage.

Under this classification is also included ungullied land which was once cropped, but has subsequently been abandoned and now supports some pasturage.

Pasture land, gullied.—All permanent pasture land which is gullied, either slightly or badly, but which can be pastured without difficulty. Because of its high degree of erosiveness, most of this type of land is not adapted to cultivation. Some of the less sloping areas could possibly be safely cropped, provided efficient terraces were immediately constructed. The presence of gullies, however, makes terracing expensive on this type of land.

Rough broken land.—Uncropped land which is so badly gullied, and dissected by gullies and ravines as to be of low value, even for pasture. Such land is in a condition that makes it entirely unsuitable for reclamation. It is seldom timbered, except by a scattering of mesquite and other shrub growth. Some of this land was formerly cultivated but the greater part has never been plowed. Part of it was probably in a rough condition before occupancy of the region by white man, and an undetermined part has suffered seriously from erosion because of overgrazing.

Rough stony land.—Hilly, stony land, usually timbered or covered with cedar and other bushy growths, and wholly unfit for cultivation, though not badly gullied. This land usually affords some pasturage. Most of the "cedar breaks" country is included in this classification.

Woodland, not gullied.—All timbered land not classed as rough stony land, which is not noticeably gullied. In places, where the timber is not too dense, a fair growth of grass occurs, affording some pasturage for livestock.

Woodland, gullied.—Timbered land not classed as rough stony land, which has been distinctly dissected by well-defined gullies. This type of land, due to its erosiveness, should not be cleared for cultivation, unless it is to be immediately developed into permanent pasture or meadow.

Watershed.—The total area which is included within the boundaries of the watershed of the Brazos River.

The Brazos River Conservation and Reclamation District.—The total area of all counties which are wholly or partly included in the watershed of the Brazos River.

TABLE 1.—*Extent of erosion, in entire Brazos River watershed, by counties, for land in cultivation* [1]

County	Percent of county in watershed	Area in watershed	Cultivated land in watershed		No erosion			Sheet erosion (not terraced)			Slightly gullied (not terraced)			Badly gullied (not terraced)			Abandoned due to gullying			Terraced		
			Area	Watershed area in county	Area	Watershed area in county	Cultivated land	Area	Watershed area in county	Cultivated land	Area	Watershed area in county	Cultivated land	Area	Watershed area in county	Cultivated land	Area	Watershed area in county	Cultivated land	Area	Watershed area in county	Cultivated land
		Acres	*Acres*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*
Archer	2.9	16,000	2,384	14.9	105	0.7	4.4	1,762	10.9	73.9	398	2.5	16.7	24	0.2	1.0				95	0.6	4.0
Austin	74.7	348,160	91,510	26.3	23,152	6.6	25.3	59,115	17.0	64.6	8,693	2.5	9.5	275	.1	.3				275	.1	.3
Bailey	86.1	567,680	182,225	32.1	40,272	7.1	22.1	140,860	24.8	77.3	547	.1	.3							547	.1	.3
Bastrop	7.2	39,680	11,758	29.6				6,737	17.0	57.3	3,868	9.7	32.9	306	.8	2.6	517	1.3	4.4	329	.8	2.8
Baylor	47.5	267,520	53,049	19.8	2,334	.9	4.4	39,203	14.6	73.9	7,639	2.9	14.4	902	.3	1.7				2,971	1.1	5.6
Bell	100.0	693,120	334,666	48.3	669	.1	.2	167,333	24.2	50.0	44,910	20.9	43.3	16,399	2.4	4.9	1,004	.1	.3	4,351	.6	1.3
Borden	.4	2,560	142	5.6				132	5.2	93.0	10	.4	7.0									
Bosque	100.0	624,000	186,151	29.8	5,957	1.0	3.2	133,098	21.2	71.5	37,975	6.1	20.4	3,537	.6	1.9	558	.1	.3	5,026	.8	2.7
Brazoria	32.6	279,680	22,357	8.0	18,892	6.8	84.5	3,465	1.2	15.5												
Brazos	100.0	382,080	115,668	30.3	37,476	9.8	32.4	65,815	17.3	56.9	5,899	1.5	5.1	1,157	.3	1.0				5,321	1.4	4.6
Brown	3.5	21,120	6,071	28.7	49	.2	.8	3,181	15.1	52.4	2,289	10.8	37.7	231	1.1	3.8	18	.1	.3	304	1.4	5.0
Burleson	100.0	437,760	119,882	27.4	1,678	.4	1.4	83,438	19.0	69.6	27,453	6.3	22.9	2,278	.5	1.9	240	.1	.2	4,795	1.1	4.0
Burnet	49.1	305,920	48,777	15.9				33,705	10.9	69.1	11,560	3.8	23.7	585	.2	1.2				2,927	1.0	6.0
Callahan	61.0	333,440	64,312	19.3				24,503	7.3	38.1	27,783	8.4	43.2	3,087	.9	4.8	1,865	.6	2.9	7,074	2.1	11.0
Castro	32.4	185,600	125,280	67.5	45,602	24.6	36.4	79,553	42.8	63.5										125	.1	.1
Cochran	5.3	29,440	5,565	18.9				5,537	18.8	95.5							28	.1	.5			
Comanche	97.7	592,640	184,943	31.2	1,480	.2	.8	91,917	15.5	49.7	69,724	11.8	37.7	7,028	1.2	3.8	555	.1	.3	14,241	2.4	7.7
Coryell	100.0	694,400	238,105	34.3	476	.1	.2	154,530	22.2	64.9	71,908	10.4	30.2	3,333	.5	1.4				7,857	1.1	3.3
Crosby	99.7	554,880	286,873	51.7	49,342	8.9	17.2	232,080	41.8	80.9	574	.1	.2							4,877	.9	1.7
Dickens	66.6	375,680	88,726	23.6	6,388	1.7	7.2	76,571	20.3	86.3	1,153	.3	1.3	266	.1	.3				4,348	1.2	4.9
Eastland	95.7	566,400	122,965	21.7				55,949	9.8	45.5	51,891	9.2	42.2	2,828	.5	2.3				12,297	2.2	10.0
Erath	100.0	693,120	190,610	27.6	1,144	.2	.6	79,484	11.5	41.7	81,962	11.8	43.0	5,528	.8	2.9	572	.1	.3	21,920	3.2	11.5
Falls	100.0	476,800	289,547	60.8	6,370	1.3	2.2	196,023	41.1	67.7	60,515	12.7	20.9	12,161	2.6	4.2	1,734	.4	.6	12,740	2.7	4.4
Fayette	1.9	10,880	979	9.0				800	7.3	81.7	164	1.5	16.8	5	.1	.5				10	.1	1.0
Fisher	100.0	566,400	182,338	32.2	11,852	2.1	6.5	95,545	16.9	52.4	39,385	7.0	21.6	729	.1	.4				34,827	6.1	19.1
Floyd	43.6	282,240	204,060	72.3	75,298	26.7	36.9	127,333	45.1	62.4										1,428	.5	.7
Fort Bend	85.9	435,200	142,753	32.8	108,778	25.0	76.2	33,690	7.7	23.6	286	.1	.2									
Freestone	12.5	70,400	16,243	23.1				11,809	16.8	72.7	3,249	4.6	20.0	374	.5	2.3	49	.1	.3	763	1.1	4.7

Garza	98.7	549,760	76,871	14.0	13,837	2.5	18.0	51,580	9.4	67.1	384	.1	.5						11,069	2.0	14.4
Grimes	58.0	301,440	67,816	22.4	407	.1	.6	50,387	16.7	74.3	11,936	4.0	17.6	1,628	.5	2.4	610	.2	.9	2,848	.9	4.2
Hale	96.4	639,360	464,815	72.7	94,822	14.8	20.4	364,415	57.1	78.4	1,394	.2	.3	930	.1	.2				3,254	.5	.7
Hamilton	100.0	533,120	165,850	31.1				114,437	21.5	69.0	38,975	7.3	23.5	1,327	.2	.8	498	.1	.3	10,614	2.0	6.4
Haskell	100.0	590,720	258,791	43.8	2,847	.5	1.1	197,458	33.4	76.3	30,537	5.2	11.8	2,847	.5	1.1				25,103	4.2	9.7
Hill	68.6	424,320	280,599	66.1	842	.2	.3	183,512	43.3	65.4	73,517	17.3	26.2	12,066	2.8	4.3	1,122	.3	.4	9,540	2.2	3.4
Hockley	64.4	357,120	159,632	44.7	10,376	2.9	6.5	148,138	41.5	92.8										1,117	.3	.7
Hood	100.0	259,200	70,179	27.1				37,686	14.5	53.7	20,843	8.0	29.7	3,509	1.4	5.0	1,263	.5	1.8	6,878	2.7	9.8
Jack	29.9	184,320	27,692	15.0	582	.3	2.1	11,132	6.0	40.2	12,461	6.8	45.0	1,163	.6	4.2				2,354	1.3	8.5
Johnson	50.0	236,800	116,300	49.1				73,269	30.8	63.0	32,797	13.9	28.2	5,117	2.2	4.4	698	.3	.6	4,419	1.9	3.8
Jones	100.0	590,080	276,171	46.8	19,056	3.2	6.9	199,948	33.9	72.4	22,646	3.8	8.2	276	.1	.1				34,245	5.8	12.4
Kent	100.0	560,000	51,394	9.2	206	.1	.4	45,638	8.1	88.8	4,523	.8	8.8	617	.1	1.2				411	.01	.8
King	42.8	237,440	7,604	3.2	1,224	.5	16.1	5,156	2.2	67.8	243	.1	3.2							981	.4	12.9
Knox	55.6	306,560	87,692	28.6	4,209	1.4	4.8	74,275	24.2	84.7	4,911	1.6	5.6	614	.2	.7				3,683	1.2	4.2
Lamb	100.0	654,080	376,096	57.5	24,822	3.8	6.6	346,008	52.9	92.0	752	.1	.2	752	.1	.2				3,761	.6	1.0
Lampasas	80.0	378,880	63,501	16.8	1,715	.5	2.7	34,735	9.1	54.7	23,686	6.3	37.3	826	.2	1.3				2,540	.7	4.0
Lee	95.0	341,760	76,048	22.3				60,914	17.9	80.1	12,700	3.7	16.7	380	.1	.5	913	.3	1.2	1,141	.3	1.5
Leon	28.0	197,120	33,181	16.8				23,227	11.7	70.0	6,802	3.5	20.5	564	.3	1.7	1,161	.6	3.5	1,427	.7	4.3
Limestone	89.7	559,360	304,372	54.5	609	.1	.2	160,404	28.7	52.7	85,529	15.3	28.1	14,001	2.5	4.6	913	.2	.3	42,916	7.7	14.1
Lubbock	100.0	555,520	359,977	64.8	83,875	15.1	23.3	262,063	47.2	72.8	720	.1	.2							13,319	2.4	3.7
Lynn	45.6	252,160	139,444	55.3	26,494	10.5	19.0	109,185	43.3	78.3										3,765	1.5	2.7
McLennan	100.0	671,360	457,417	68.1	18,754	2.8	4.1	223,219	33.2	48.8	175,648	26.2	38.4	10,063	1.5	2.2	5,032	.7	1.1	24,701	3.7	5.4
Madison	16.6	52,480	13,840	26.4				11,460	21.8	82.8	1,522	2.9	11.0	97	.2	.7	28	.1	.2	734	1.4	5.3
Milam	100.0	613,760	320,308	52.2	7,047	1.1	2.2	147,662	24.1	46.1	124,600	20.3	38.9	20,820	3.4	6.5	4,805	.8	1.5	15,375	2.5	4.8
Mills	36.1	160,640	34,596	21.6	104	.1	.3	22,695	14.1	65.6	8,960	5.6	25.9	657	.4	1.9				2,180	1.4	6.3
Nolan	49.1	276,480	60,815	22.0	10,339	3.7	17.0	37,644	13.7	61.9	5,595	2.0	9.2	487	.2	.8				6,750	2.4	11.1
Palo Pinto	100.0	613,120	81,932	13.4	410	.1	.5	48,668	7.9	59.4	27,857	4.6	34.0	1,229	.2	1.5				3,769	.6	4.6
Parker	51.4	288,000	86,733	30.1	607	.2	.7	47,877	16.6	55.2	18,908	6.6	21.8	3,469	1.2	4.0	6,418	2.2	7.4	9,454	3.3	10.9
Parmer	64.1	369,920	210,854	57.0	23,405	6.3	11.1	185,762	50.3	88.1	422	.1	.2	422	.1	.2				843	.2	.4
Robertson	100.0	558,080	208,208	37.3	3,956	.7	1.9	161,778	29.0	77.7	27,275	4.9	13.1	3,956	.7	1.9	2,498	.4	1.2	8,745	1.6	4.2
Scurry	42.3	240,000	61,604	25.7	1,848	.8	3.0	47,127	19.7	76.5	1,540	.6	2.5	185	.1	.3				10,904	4.5	17.7
Shackelford	100.0	606,080	51,340	8.5	411	.1	.8	38,710	6.4	75.4	7,855	1.3	15.3	873	.1	1.7				3,491	.6	6.8
Somervell	100.0	117,760	28,956	24.5	376	.3	1.3	11,438	9.7	39.5	10,916	9.3	37.7	1,824	1.5	6.3	1,911	1.6	6.6	2,490	2.1	8.6
Stephens	100.0	592,000	54,735	9.3	1,040	.2	1.9	34,757	5.9	63.5	14,778	2.5	27.0	712	.1	1.3				3,448	.6	6.3
Stonewall	100.0	545,280	68,985	12.7	5,174	.9	7.5	48,496	9.0	70.3	9,934	1.8	14.4	759	.1	1.1	207	.1	.3	4,415	.8	6.4
Swisher	7.5	42,880	28,601	66.7	1,888	4.4	6.6	26,628	62.1	93.1										86	.2	.3
Taylor	64.8	376,320	148,778	39.6	5,951	1.6	4.0	103,698	27.6	69.7	31,690	8.4	21.3	1,488	.4	1.0				5,951	1.6	4.0
Throckmorton	100.0	562,560	61,165	10.9	2,324	.4	3.8	42,326	7.5	69.2	14,496	2.6	23.7	367	.1	.6				1,651	.3	2.7
Waller	67.6	224,640	49,206	21.9	8,611	3.8	17.5	38,824	17.3	78.9	1,427	.6	2.9							344	.2	.7
Washington	100.0	401,920	140,168	34.9	2,243	.6	1.6	105,226	26.3	75.1	22,707	5.6	16.2	561	.1	.4	841	.2	.6	8,550	2.1	6.1
Williamson	100.0	722,560	402,877	55.8	6,446	.9	1.6	271,539	37.6	67.4	76,547	10.6	19.0	19,338	2.7	4.8	4,432	.6	1.1	24,575	3.4	6.1
Young	92.2	516,480	130,725	25.3	915	.2	.7	68,108	13.2	52.1	49,283	9.5	37.7	2,353	.5	1.8				10,066	1.9	7.7

[1] The area of each county in the watershed was computed by the State drainage and reclamation department.

TABLE 2.—*Extent of erosion, in entire Brazos River watershed, by counties, for land not in cultivation*

County	Uncultivated land in watershed area																	
	Uncultivated land in watershed		Pasture land not gullied			Pasture land gullied			Rough broken land			Rough stony land			Woodland not gullied			Woodland gullied		
	Portion of watershed	Area	Area	Watershed area in county	Uncultivated land	Area	Watershed area in county	Uncultivated land	Area	Watershed area in county	Uncultivated land	Area	Watershed area in county	Uncultivated land	Area	Watershed area in county	Uncultivated land	Area	Watershed area in county	Uncultivated land
	Percent	*Acres*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*
Archer	85.1	13,616	7,884	49.3	57.9	5,392	33.7	39.6	68	0.4	0.5				272	1.7	2.0			
Austin	73.7	256,650	158,353	45.5	61.7	25,152	7.2	9.8							65,959	18.9	25.7	7,186	2.1	2.8
Bailey	67.9	385,455	380,444	67.0	98.7	5,011	.9	1.3												
Bastrop	70.4	27,922	10,219	25.8	36.6	2,736	6.9	9.8							14,101	35.5	50.5	866	2.2	3.1
Baylor	80.2	214,471	115,814	43.3	54.0	85,574	32.0	39.9	8,793	3.3	4.1				4,289	1.6	2.0			
Bell	51.7	358,454	89,614	12.9	25.0	48,033	6.9	13.4				110,762	16.0	30.9	94,990	13.7	26.5	15,055	2.2	4.2
Borden	94.4	2,418	1,545	60.3	63.9	825	32.2	34.1	48	1.9	2.0									
Bosque	70.2	437,849	143,614	23.0	32.8	73,121	11.7	16.7				22,330	3.6	5.1	166,820	26.8	38.1	31,963	5.1	7.3
Brazoria	92.0	257,323	190,419	68.1	74.0	772	.3	.3							66,132	23.6	25.7			
Brazos	69.7	266,412	142,797	37.3	53.6	22,379	5.9	8.4							85,785	22.5	32.2	15,452	4.0	5.8
Brown	71.3	15,049	5,839	27.7	38.8	4,861	23.1	32.3				301	1.4	2.0	2,859	13.5	19.0	1,189	5.6	7.9
Burleson	72.6	317,878	82,966	19.0	26.1	31,470	7.2	9.9							168,793	38.5	53.1	34,649	7.9	10.9
Burnet	84.1	257,143	130,886	42.7	50.9	72,771	23.8	28.3				2,314	.8	.9	42,686	14.0	16.6	8,846	2.8	3.3
Callahan	80.7	269,128	138,870	41.7	51.6	104,691	31.4	38.9				10,765	3.2	4.0	11,034	3.3	4.1	3,768	1.1	1.4
Castro	32.5	60,320	59,596	32.1	98.8	724	.4	1.2												
Cochran	81.1	23,875	23,875	81.1	100.0															
Comanche	68.8	407,697	158,816	26.7	38.8	131,686	22.2	32.3				8,154	1.4	2.0	77,462	13.1	19.0	32,208	5.4	7.9
Coryell	65.7	456,295	195,294	28.2	42.8	75,289	10.8	16.5				59,318	8.5	13.0	103,579	14.9	22.7	22,815	3.3	5.0
Crosby	48.3	268,007	205,829	37.1	76.8	46,097	8.3	17.2	16,080	2.9	6.0									
Dickens	76.4	286,954	188,816	50.3	65.8	32,426	8.6	11.3	65,712	17.5	22.9									
Eastland	78.3	443,435	152,542	26.9	34.4	137,465	24.3	31.0				25,276	4.5	5.7	87,357	15.4	19.7	40,796	7.2	9.2
Erath	72.4	502,510	185,929	26.8	37.0	158,793	22.9	31.6				19,598	2.8	3.9	94,472	13.6	18.8	43,718	6.3	8.7
Falls	39.2	187,253	120,965	25.4	64.6	40,634	8.5	21.7							23,032	4.8	12.3	2,622	.5	1.4
Fayette	91.0	9,910	2,436	22.4	24.6	703	6.5	7.1							5,911	54.3	59.7	851	7.8	8.6
Fisher	67.8	384,062	210,466	37.2	54.8	159,770	28.2	41.6	13,826	2.4	3.6									
Floyd	27.7	78,180	75,366	26.7	96.4	1,955	.7	2.5	860	.3	1.1									
Fort Bend	67.2	292,447	246,533	56.7	84.3	8,481	1.9	2.9							34,509	7.9	11.8	2,924	.7	1.0
Freestone	76.9	54,157	12,619	17.9	23.3	4,062	5.8	7.5							32,873	46.7	60.7	4,603	6.5	8.5
Garza	86.0	472,889	309,269	56.3	65.4	131,463	23.9	27.8	32,156	5.8	6.8									
Grimes	77.6	233,624	99,757	33.1	42.7	49,295	16.4	21.1							67,751	22.5	29.0	16,821	5.6	7.2

Hale	27.3	174,545	173,847	27.2	99.6	698	.1	.4											
Hamilton	68.9	367,270	197,224	37.0	53.7	71,985	13.5	19.6				12,487	2.3	3.4	59,130	11.1	16.1	26,443	5.0	7.2
Haskell	56.2	331,929	261,560	44.3	78.8	68,377	11.6	20.6	1,992	.3	.6									
Hill	33.9	143,721	63,525	15.0	44.2	57,776	13.6	40.2							12,360	2.9	8.6	10,060	2.4	7.0
Hockley	55.3	197,488	197,093	55.2	99.8	395	.1	.2												
Hood	72.9	189,021	83,358	32.2	44.1	32,701	12.6	17.3	1,134	.4	.6	11,341	4.4	6.0	45,932	17.7	24.3	14,555	5.6	7.7
Jack	85.0	156,628	54,820	29.9	35.0	39,470	21.4	25.2				2,663	1.4	1.7	88,061	20.6	24.3	21,615	11.7	13.8
Johnson	50.9	120,500	58,804	24.8	48.8	40,850	17.3	33.9				6,025	2.5	5.0	11,327	4.8	9.4	3,495	1.5	2.9
Jones	53.2	313,909	196,821	33.4	62.7	77,222	13.1	24.6	1,883	.3	.6				37,983	6.4	12.1			
Kent	90.8	508,606	302,112	53.9	59.4	159,702	28.5	31.4	46,792	8.4	9.2									
King	96.8	229,836	91,934	38.7	40.0	124,111	52.3	54.0	13,790	5.8	6.0									
Knox	71.4	218,868	143,359	46.8	65.5	54,279	17.7	24.8	21,230	6.9	9.7									
Lamb	42.5	277,984	275,482	42.1	99.1	2,502	.4	.9												
Lampasas	83.2	315,379	178,189	47.0	56.5	59,607	15.7	18.9				3,469	.9	1.1	54,561	14.4	17.3	19,553	5.2	6.2
Lee	77.7	265,712	65,365	19.1	24.6	18,866	5.5	7.1							158,630	46.4	59.7	22,851	6.7	8.6
Leon	83.2	163,939	29,345	14.9	17.9	21,804	11.1	13.3							97,216	49.3	59.3	15,574	7.9	9.5
Limestone	45.5	254,988	110,920	19.8	43.5	52,783	9.4	20.7							71,652	12.8	28.1	19,634	3.5	7.7
Lubbock	35.2	195,543	182,637	32.9	93.4	8,408	1.5	4.3	4,497	.8	2.3									
Lynn	44.7	112,716	110,913	44.0	98.4	1,803	.7	1.6												
McLennan	31.9	213,943	78,731	11.8	36.8	57,337	8.5	26.8				1,712	.3	.8	61,402	9.1	28.7	14,762	2.2	6.9
Madison	73.6	38,640	13,640	26.0	35.3	4,946	9.4	12.8							16,654	31.7	43.1	3,400	6.5	8.8
Milam	47.8	293,452	99,187	16.2	33.8	44,018	7.2	15.0							121,196	19.7	41.3	29,052	4.7	9.9
Mills	78.4	126,044	50,292	31.3	39.9	23,318	14.5	18.5				10,336	6.4	8.2	37,813	23.5	30.0	4,285	2.7	3.4
Nolan	78.0	215,665	100,931	36.5	46.8	108,695	39.3	50.4	6,039	2.2	2.8									
Palo Pinto	86.6	531,188	202,383	33.0	38.1	169,980	27.7	32.0				75,960	12.4	14.3	28,153	4.6	5.3	54,712	8.9	10.3
Parker	69.9	201,267	72,859	25.3	36.2	35,826	12.4	17.8				2,415	.8	1.2	77,085	26.9	38.3	13,082	4.5	6.5
Parmer	43.0	159,066	155,726	42.1	97.9	3,340	.9	2.1												
Robertson	62.7	349,872	151,145	27.1	43.2	40,935	7.3	11.7				1,050	.2	.3	147,646	26.5	42.2	9,097	1.6	2.6
Scurry	74.3	178,396	113,995	47.5	63.9	58,157	24.2	32.6	6,244	2.6	3.5									
Shackelford	91.5	554,740	383,325	63.2	69.1	163,094	26.9	29.4	7,766	1.3	1.4				555	.1	.1			
Somervell	75.5	88,804	17,850	15.2	20.1	19,981	17.0	22.5				23,799	20.2	26.8	19,626	16.7	22.1	7,548	6.4	8.5
Stephens	90.7	537,265	270,244	45.6	50.3	171,925	29.0	32.0				10,745	1.8	2.0	41,369	7.0	7.7	42,981	7.3	8.0
Stonewall	87.3	476,295	201,473	36.9	42.3	252,913	46.4	53.1	21,910	4.0	4.6									
Swisher	33.3	14,279	14,279	33.3	100.0															
Taylor	60.4	227,542	94,202	25.0	41.4	118,322	31.4	52.0	14,563	3.9	6.4				455	.1	.2			
Throckmorton	89.1	501,395	329,918	58.6	65.8	154,430	27.5	30.8	16,546	2.9	3.3				501	.1	.1			
Waller	78.1	175,434	130,347	58.0	74.3	10,000	4.5	5.7							31,403	14.0	17.9	3,684	1.6	2.1
Washington	65.1	261,752	127,735	31.8	48.8	49,209	12.2	18.8							69,364	17.3	26.5	15,443	3.8	5.9
Williamson	44.2	319,683	102,938	14.2	32.2	51,469	7.1	16.1				2,557	.4	.8	147,374	20.4	46.1	15,345	2.1	4.8
Young	74.7	385,755	162,017	31.4	42.0	104,925	20.3	27.2	16,587	3.2	4.3				40,504	7.8	10.5	61,721	12.0	16.0

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REGIONAL SECTIONS OF WATERSHED

The State of Texas comprises 11 major physiographic and soil divisions. Seven of these are crossed by the Brazos River. Each section of the Brazos watershed is characterized by soil and climatic conditions differing in some respects from the others, and for this reason each is classed as a unit in presenting the details of this survey and each will be discussed separately.

The watershed area embraces also a very small portion of another section, which is not of sufficient size to be considered separately. This is a fragmentary area of the Edwards Plateau section, lying partly within Nolan and Taylor Counties. It adjoins the southern extremity of the Rolling Plains section of the watershed, and is described as a part of that section.

FIGURE 2.—The major physiographic sections (solid lines) and boundaries of Brazos River watershed (heavy dotted lines).

The regional sections are listed below together with the counties that lie wholly or partly within each of these sections. They are shown on the map [4] in figure 2.

COUNTIES WHOLLY OR PARTLY IN EACH SECTION

High Plains Section: Bailey, Castro, Cochran, Crosby, Dickens, Floyd, Hale, Garza, Hockley, Lamb, Lubbock, Lynn, Parmer, Swisher.

[4] CARTER, W. T. THE SOILS OF TEXAS. Tex. Agr. Expt. Sta. Bul. 431, 192 p., illus. 1931.

Rolling Plains Section: Archer, Baylor, Borden, Callahan, Crosby, Dickens, Eastland, Fisher, Garza, Haskell, Jones, Kent, King, Knox, Nolan, Scurry, Shackelford, Stephens, Stonewall, Taylor, Throckmorton, Young.

West Cross Timbers (and associated prairies) Section: Brown, Callahan, Comanche, Eastland, Erath, Hood, Jack, Palo Pinto, Parker, Shackelford, Stephens, Throckmorton, Young.

Grand Prairie Section: Bell, Bosque, Brown, Burnet, Comanche, Coryell, Erath, Hamilton, Hill, Hood, Johnson, Lampasas, McLennan, Mills, Parker, Somervell, Williamson.

Blackland Prairie (and minor dark soil prairies) Section: Austin, Bastrop, Bell, Brazos, Burleson, Falls, Fayette, Grimes, Hill, Lee, Limestone, McLennan, Milam, Robertson, Washington, Williamson.

East Texas Timber Country Section (including portion of East Cross Timbers): Austin, Bastrop, Brazos, Burleson, Falls, Fayette, Freestone, Grimes, Hill, Johnson, Lee, Leon, Limestone, Madison, Milam, Robertson, Waller, Washington, Williamson.

Coast Prairie Section: Austin, Brazoria, Fort Bend, Waller.

EXTENT OF EROSION IN WATERSHED

The extent (and kinds) of erosion in the entire Brazos River watershed, and in each of the seven regional divisions, as it affects cultivated land, woodland, and pasture, is shown in table 3.

TABLE 3.—*Extent of erosion in watershed by regional sections*

Section	Approximate area of section in watershed	Cultivated land				
		Total	Suffering from sheet erosion		Gullied (not terraced)	
			Area	Cultivated land	Area	Cultivated land
	Acres	*Acres*	*Acres*	*Percent*	*Acres*	*Percent*
High Plains	4,360,960	2,500,051	1,989,310	79.6	6,624	0.3
Rolling Plains	7,100,086	1,636,285	1,179,881	72.1	222,292	13.6
West Cross Timbers (and associated prairies)	3,497,290	709,217	319,747	45.1	295,486	41.7
Grand Prairies	4,908,125	1,550,373	944,211	60.9	447,745	28.9
Blackland Prairies (and minor dark soil prairies)	2,958,627	1,820,615	1,081,827	59.4	697,609	38.3
East Texas Timber Country (with portion of East Cross Timbers)	3,276,422	1,031,834	682,604	66.2	224,327	21.7
Coast Prairie	1,012,730	235,432	82,797	35.2	868	.4
Total	27,114,240	9,483,807	6,280,377	66.2	1,894,951	20.0

Section	Pasture (including rough broken and rough stony land)			Woodland			Approximate annual average rainfall [1]
	Total	Gullied		Total	Gullied		
		Area	Pasture		Area	Woodland	
	Acres	*Acres*	*Percent*	*Acres*	*Acres*	*Percent*	*Inches*
High Plains	1,860,909	43,983	2.4				21.80
Rolling Plains	5,405,507	2,161,015	40.0	58,294	3,523	6.0	23.58
West Cross Timbers (and associated prairies)	2,088,532	1,028,058	49.2	699,700	287,865	41.1	27.26
Grand Prairies	2,345,970	972,380	41.4	1,011,623	191,852	19.0	31.86
Blackland Prairies (and minor dark soil prairies)	819,765	231,802	28.3	318,247	59,792	18.8	36.83
East Texas Timber Country (with portion of East Cross Timbers)	1,084,713	289,118	26.7	1,159,875	167,312	14.4	37.30
Coast Prairie	631,645	13,327	2.1	145,653	4,524	3.1	42.84
Total	14,237,041	4,739,683	33.3	3,393,392	714,868	21.1	

[1] The annual average rainfall was computed from records obtained from 40 counties within the watershed.

A somewhat more detailed summary of the extent of erosion in the watershed area is contained in table 4 which shows the extent of flatland and differentiates between land that is slightly gullied, badly gullied, and abandoned because of gullying. The acreage of rough stony land and rough broken land which are included under pasture in table 3 are given separately in table 4 which also includes the percentage relationships of the acreages of various classes of land to the entire acreage of the watershed area.

TABLE 4.—*Area and percentage of eroded and uneroded land in actual watershed area*

CULTIVATED

Class of land	Area	Condition	Cultivated land	Watershed
	Acres		*Percent*	*Percent*
Flatland, very little erosion	825,088	Eroded	8.7	3.0
Land subject to sheet erosion, but not gullied	6,280,377	do	66.2	23.2
Land slightly gullied, not terraced	1,677,151	do	17.7	6.2
Land badly gullied, not terraced	177,310	do	1.9	.7
Terraced (terraces holding reasonably well); contoured land not included	483,355	do	5.1	1.8
Land abandoned due to gullying	40,490	do	.4	.14
Cultivated land, gullied but not terraced	1,894,951	do	20.0	7.0
Cultivated land suffering from sheet erosion and gullying	8,175,328	do	86.2	30.2

UNCULTIVATED

Class of land	Area	Condition	Pasture land	Watershed	Uncultivated land
	Acres		*Percent*	*Percent*	*Percent*
Pasture land, not gullied (no timber or only scattered tree growth) [1]	9,497,358		66.7	35.0	53.9
Pasture land, gullied	3,997,790	Eroded	28.0	14.7	22.7
Rough stony land	423,377	do	3.0	1.6	2.4
Rough broken land	318,516	do	2.2	1.2	1.8
WOODLAND					
Woodland, not appreciably gullied	2,678,524	do	78.9	9.9	15.2
Woodland, gullied	714,868	do	21.1	2.6	4.1
Uncultivated land not suitable for cultivation [2]	5,454,547	do		20.1	30.9

[1] Degree of sheet erosion not determined.
[2] Includes gullied pasture, gullied woodland, rough broken land, and rough stony land.

The High Plains section within the watershed, containing parts or the whole of 12 counties, has a total area of 4,360,960 acres which constitutes 16.6 percent of the watershed. The area of cultivated land is 2,500,051 acres or 56.6 percent of the section. Table 5 shows the extent of erosion in the High Plains section in more detail than table 3 since it includes flatland, terraced land, and lands slightly and badly gullied.

TABLE 5.—*Area and percentage of eroded and uneroded land in High Plains section of watershed*

CULTIVATED

Class of land	Area	Condition	Cultivated land	Watershed
	Acres		*Percent*	*Percent*
Flatland	470,995	Uneroded	18.8	10.8
Subject to sheet erosion	1,989,310	Eroded	79.6	45.6
Slightly gullied (not terraced)	4,520	do	.2	.1
Badly gullied (not terraced)	2,104	do	.1	.05
Terraced	33,122	Uneroded	1.3	.8

TABLE 5.—*Area and percentage of eroded and uneroded land in High Plains section of watershed*—Continued

UNCULTIVATED

Class of land	Area	Condition	Pasture land	Watershed
	Acres		*Percent*	*Percent*
Pasture land, not gullied [1]	1,816,926		97.6	41.7
Pasture land, gullied (including rough broken land)	43,983	Eroded	2.4	1.0

[1] Degree of sheet erosion not determined.

The extent of erosion in the watershed below the High Plains is given in detail in table 6 which shows the acreages of cultivated land slightly gullied, badly gullied, terraced, and abandoned due to gullying, and includes several categories under uncultivated land, not included in table 3. The watershed area below the High Plains is 22,623,360 acres in extent and constitutes 83.4 percent of the entire watershed. Of this area, 6,940,385 acres, or 30.7 percent, is cultivated, and 15,682,975 acres, or 69.3 percent is uncultivated.

TABLE 6.—*Area and percentage of eroded and uneroded land in the watershed below the High Plains*

CULTIVATED

Class of land	Area	Condition	Cultivated land	Watershed
	Acres		*Percent*	*Percent*
Flatland	354,093	Uneroded	5.1	1.6
Subject to sheet erosion	4,291,067	Eroded	61.4	18.9
Slightly gullied	1,672,631	do	24.0	7.4
Badly gullied	175,206	do	2.5	.8
Terraced	450,233	Uneroded	6.4	2.0
Abandoned, due to gullying [1]	40,490	Eroded	.6	.2

UNCULTIVATED

Class of land	Area	Condition	Pasture land	Uncultivated land	Watershed
	Acres		*Percent*	*Percent*	*Percent*
Pasture land not gullied [2]	7,680,432		62.1	48.7	33.8
Pasture land, gullied	4,096,500	Eroded	33.1	26.0	18.0
Pasture land, rough broken	175,823	do	1.4	1.1	.8
Rough stony land	423,377	do	3.4	2.7	1.9
WOODLAND					
Woodland not gullied [2]	2,678,524		78.9	17.0	11.8
Woodland, gullied	714,867	Eroded	21.1	4.5	3.1

[1] In addition, thousands of acres, once cultivated, have been abandoned, at least temporarily, chiefly because of sheet erosion. On much of such land, particularly that which is not steeply sloping, very little gullying is apparent. These areas are listed as pasture land, since there was not sufficient time to determine definitely the reason for abandonment of the individual areas.
[2] Degree of sheet erosion not determined.

The Brazos River Conservation and Reclamation District has an area of approximately 38,977,200 acres, which includes the Brazos watershed area with approximately 27,114,240 acres. Assuming that the portion of the district lying outside of the actual watershed is

subject to about the same erosional influences as that within the watershed, the data compiled in table 7 will give a fair summary of the amount of erosion within the district.

TABLE 7.—*Area and percentage of eroded and uneroded land in conservation and reclamation district*

Class of land	Area	Condition	Percentage of cultivated land
	Acres		*Percent*
Cultivated (12,981,182 acres):			
Flatland, very little erosion	1,129,363	Eroded	8.7
Subject to sheet erosion	8,593,542	do	66.2
Slightly gullied	2,297,669	do	17.7
Badly gullied	246,642	do	1.9
Terraced	662,040	Uneroded	5.1
Abandoned due to gullying	51,925	Eroded	.4
Land gullied (not terraced)	2,596,236	do	20.0
Land subject to sheet erosion; gullied and abandoned (not terraced)	11,189,779	do	86.2
Uncultivated (25,996,018 acres):			
Pasture land, not gullied [1]	14,011,854		53.9
Pasture land, gullied	5,901,096	Eroded	22.7
Rough broken land	467,928	do	1.8
Rough stony land	623,904	do	2.4
Woodland, not appreciably gullied [2]	3,951,395	do	15.2
Woodland, gullied	1,065,837	do	4.1
Uncultivated land not suitable for cultivation [2 3]	8,058,765	do	30.9

[1] Degree of sheet erosion not determined.
[2] There are also large areas of woodland, not gullied, which are so rolling that if cleared and cultivated, severe gullying would soon follow. These areas are not suitable for cultivation.
[3] Includes gullied pasture, gullied woodland, rough broken land, and rough stony land.

SOIL GROUPS BY SECTIONS OF WATERSHED

The soils of the Brazos River watershed are comprised in 17 major soil series groups.[5] These groups, together with their principal regional distribution are as follows:

High Plains section: Pullman-Richfield group, Amarillo sandy loams group, and Enterprise sands group.

Rolling Plains section: Abilene-Roscoe-Foard group, Vernon-rough broken land group, and Miles-Vernon group.

Edwards Plateau section: Valera-rough stony land group.

West Cross Timbers section: Windthorst-Nimrod group.

Grand Prairie section: Denton-San Saba group.

Blackland Prairie section: Houston-Wilson group and Wilson-Crockett group.

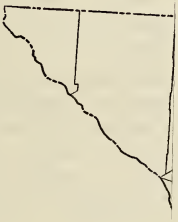
East Texas Timber Country section: Kirvin-Norfolk group and Lufkin-Susquehanna group.

Coast Prairie section: Hockley-Katy group, Lake Charles-Edna group, and Harris group.

Alluvial soils: Miller, Yahola, Trinity, Catalpa, Pledger, and Ochlockonee series.

These soil groups are shown on the general soil map of the Brazos River watershed in figure 3 and are briefly discussed in the pages following, under the descriptions of the sections in which they occur, with the exception of the alluvial soils, whose occurrence is more general. The latter are described under a separate heading.

[5] CARTER, W. T., and BEAN, A. H. PRELIMINARY RECONNAISSANCE SOIL SURVEY OF THE BRAZOS RIVER CONSERVATION AND RECLAMATION DISTRICT. Unpublished report. Also, CARTER W. T. Op. cit. (*See* footnote 4, p. 10.)



HIGH PLAINS

1 PULLMAN-RICHFIELD GROUP

2 AMARILLO SANDY LOAM GRO

3 ENTERPRISE SANDS GROUP

ROLLING PLAINS

4 ABILENE-ROSCOE-FOARD GR

5 VERNON-ROUGH BROKEN L

6 MILES-VERNON GROUP

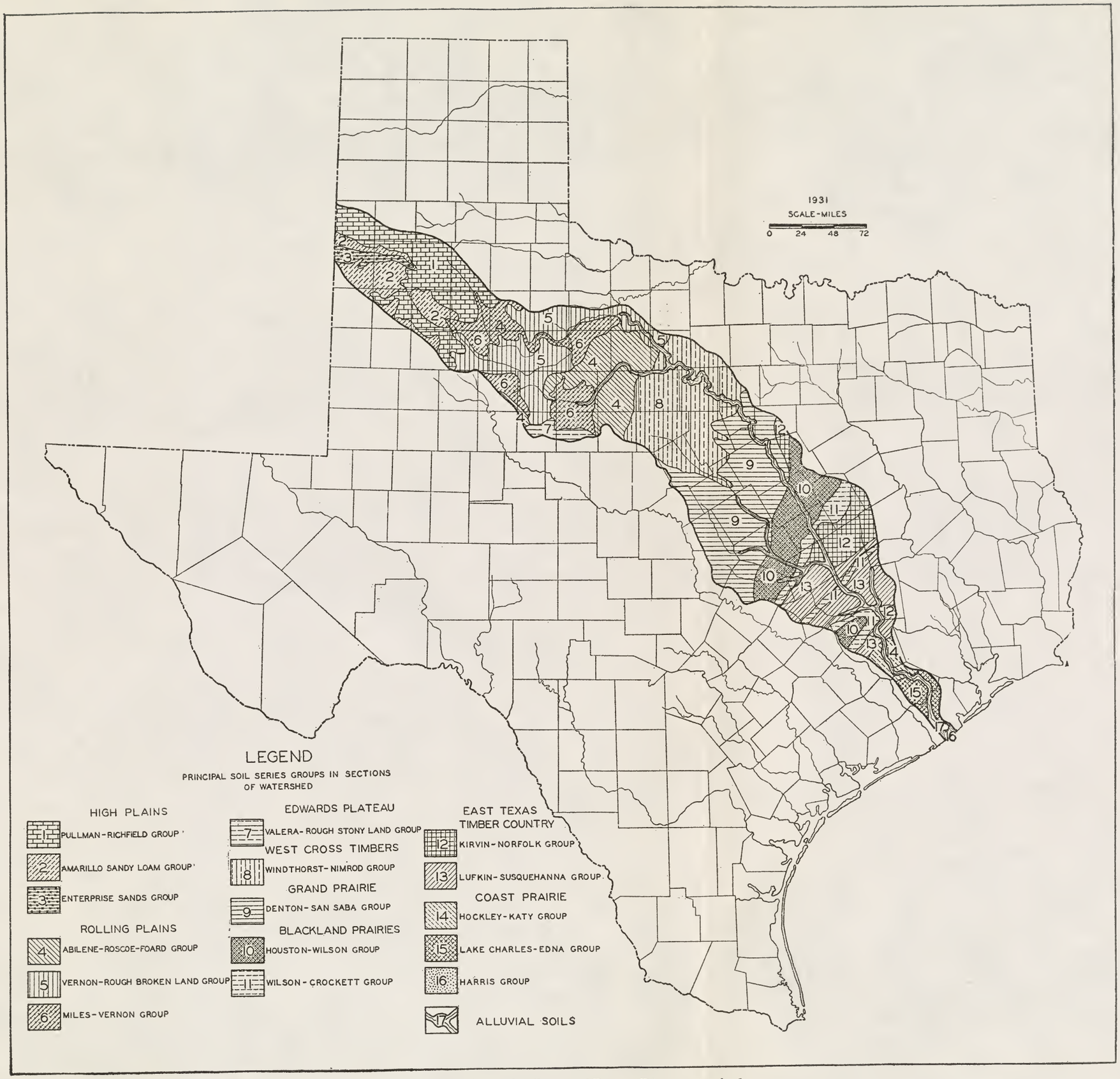


FIGURE 3.—General soil map of Brazos River watershed.

23988°—34. (Face p. 14.)

HIGH PLAINS SECTION

The counties and parts of counties included in the High Plains section are Parmer, Castro, Swisher, Bailey, Lamb, Hale, Floyd, Cochran, Hockley, Lubbock, Crosby, Dickens, Lynn, and Garza.

SOILS OF THE SECTION

PULLMAN-RICHFIELD GROUP

The Pullman soils have brown surface soils, and somewhat lighter brown subsoils. The clay loam soil type predominates. The surface soils are flat or nearly so. Water does not penetrate so rapidly as in the sandy soils, but on account of the flat relief, rain water does not run off excessively in most places. The native vegetation is mainly short grasses, chiefly buffalo, with some grama. The Richfield soils have very dark surface soils, ranging from dark brown to black. The subsoils are dark brown. The heavy types predominate. The surface relief and native vegetation are very similar to those of the Pullman clay loam.

AMARILLO SANDY LOAMS GROUP

The principal soil of the Amarillo sandy loams group is the Amarillo fine sandy loam, which occupies some large areas in the Brazos River watershed. The topsoil is a red to reddish-brown fine sandy loam 12 to 18 inches deep, grading into a subsoil of red fine sandy clay, which, at a depth of 3 to 10 feet, is underlain by sandy clay beds containing large amounts of calcium carbonate. The surface relief is undulating to gently rolling. It absorbs a large proportion of the rain water and is considered quite drought resistant. It is covered, in its native condition, by a heavy growth of grama and other grasses, and in places a characteristic growth of catclaw gives rise to the local name of "catclaw land."

ENTERPRISE SANDS GROUP

Soils of the Enterprise sands group are characterized by flat to dunelike topography and consist of loose fine sand. They are gray to light brown in color, and are underlain by reddish or yellowish subsoils. These soils have but slight value in the area for the production of cultivated crops, as they are subject to serious wind drifting wherever unprotected. There are numerous surface irregularities owing to small dunelike areas, mounds, and hillocks that have been blown up by the wind. The vegetation consists chiefly of various species of coarse grasses and small shin oak.

EROSION IN THE HIGH PLAINS SECTION

The amount of erosion which has taken place in the High Plains section of the Brazos River watershed is indicated by figure 4.

The relief of the land lying within the High Plains section is for the most part gently sloping to nearly level. A few drainageways or draws extend partly or entirely across the plains and the White River has cut a deep canyon, in places several miles wide, through Crosby County and well into Floyd County. The greater part of the drainage, however, enters comparatively shallow depressions usually having no outlets. These vary in depth from a few feet to 15 to 20 feet or more below the level of the surrounding country as shown in figure 5.

After hard rains, water stands in these low places for long periods. A considerable number are unsuitable for cultivation. Practically all the drainage of Parmer and Bailey Counties goes into these depressions, very little reaching the Brazos River, excepting from the slopes adjoining Double Mountain Fork, and Running Water Fork. These slopes usually drain back for a distance of only a mile or two on each side of the draws.

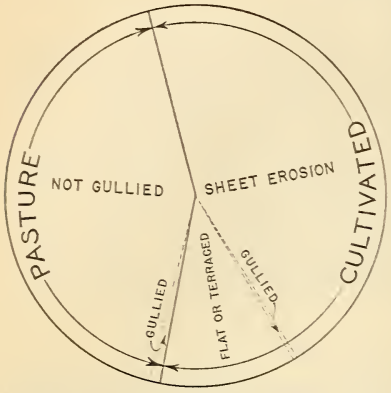


FIGURE 4.—Diagram showing extent of erosion in High Plains section of watershed. Percentages are based on total area of section as follows: Cultivated land—sheet erosion 45.6, gullied 0.1, flat or terraced 11.6, total 57.3; pasture land—gullied 1, not gullied 41.7, total 42.7; woodland—none.

In the next tier of counties eastward, Castro, Lamb, and Hockley, the drainageways mentioned, as well as Yellow House Creek, are deeper and wider and their drainage basins cover a wider area. Nevertheless, only a very small percentage of the precipitation of these counties finds its way into the Brazos River or its tributaries. This is also largely true in Lynn County. In Swisher, Hale, and Lubbock Counties the drainage system is more mature. The main waterways are deeper and they have more branches reaching out into the surrounding country. Eastward the drainage becomes better developed, until in Floyd, Crosby, Dickens, and Garza Counties some of the drainageways attain canyonlike dimensions. It is probably only a matter of time until the whole of that portion of the High

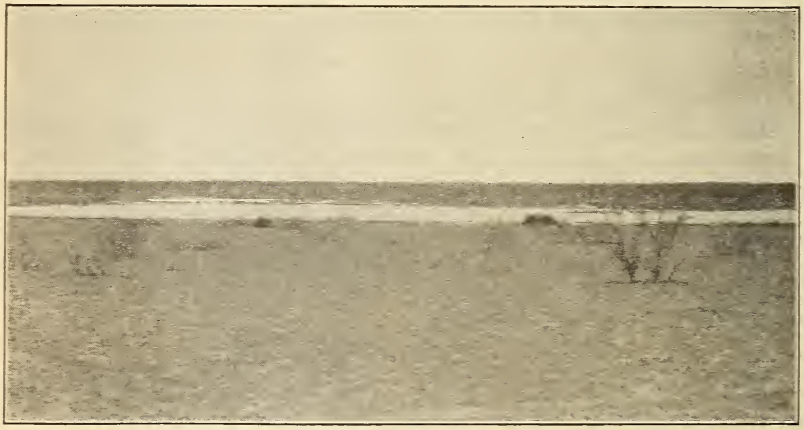


FIGURE 5.—Typical depression in High Plains section. Most of the depressions have no outlet. A single depression may receive the drainage from an area ranging from a half to several square miles in extent.

Plains country embraced within the Brazos watershed will be thoroughly dissected with drainageways.

Although the slopes of the High Plains section are for the most part gentle, considerable sheet erosion is taking place, and large deposits of fertile soil have already accumulated in the depressions. Such

washing is most severe where the land is in cultivation, although the pastures are also subject to sheet erosion, especially when heavily grazed. This survey shows that 79.6 percent of the cultivated land, which is 45.6 percent of this section of the watershed, has sufficient slope to suffer from sheet erosion. The greater part of the pasture land is also affected in this manner.

Very little gullying has taken place as yet. Only 0.3 percent of the cultivated land is noticeably gullied. This is owing largely to the smooth surface, but partly to the porous character of much of the soil, also to the comparatively light rainfall (21.8 inches) and to the fact that most of the cultivated land has been farmed for only a short time. About 2.4 percent of the pasture land is gullied. This larger percentage does not mean that pastures normally gully to a greater extent than cultivated land, simply because of pasturing. The gullies usually develop on the steeper land surrounding the deeper depressions, and on the slopes leading to the principal drainageways, and these more erosive areas have not generally been used for crops. Most of the gullies in the pastures appear to have originated from cow paths and wagon trails which led down slopes. Water concentrating in these guideways soon starts a gully in the very erosive soil. Some of these gullies have attained mammoth proportions, especially where they empty into deep drainageways.

The farmers of the High Plains section are gradually coming to realize the losses they are sustaining from soil erosion. The greatest loss, by far, is from sheet washing. This form of erosion does not make itself apparent until all or nearly all of the surface soil has been carried away. Over a period of years, the Texas Agricultural Experiment Station at Spur, has been measuring soil and water losses from land having various slopes, and the results of these tests have done much to acquaint the farmers with the large losses they are suffering from uncontrolled run-off. Although this station is just off the High Plains section of the watershed, the findings are applicable to a large percentage of this section. The soils are clay loams of the Miles and Abilene series and are somewhat similar in physical characteristics to large areas of the heavier soils of the High Plains. It has been shown that a tremendous loss of both water and soil is taking place on cultivated land having as little fall as 2 feet in 100. There is a surprising loss from cultivated land having a slope of only 1 percent, and even from level land. Holding [6] and concentrating the water on certain areas of land by means of contouring and terracing, and by bringing an additional supply of run-off water from roadways and adjoining areas, has been found to be the most effective and economical means of increasing crop yields in this region of low rainfall (fig. 6). In lessening or preventing the run-off, soil losses are also checked, thus conserving the natural fertility of the land. Tables 8, 9, and 10 give a summary of results of water-conservation experiments at the Spur station, conducted for the 6 years from 1926 to 1931 inclusive.

[6] Conner, A. B., Dickson, R. E., and Scoates, D. factors influencing run-off and soil erosion. Tex. Agr. Expt. Sta. Bul. 411, 50 p., illus. 1930.

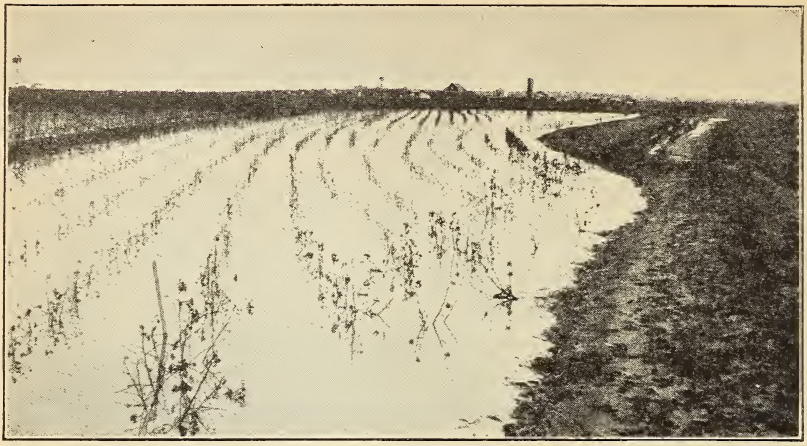


FIGURE 6.—Level terrace saving rain water, at Spur experiment station, Dickens County, Tex. One of the best ways to increase crop yields in this region.

TABLE 8.—*Water and soil losses from control plots at Spur, Tex., 6-year totals, 1926–31* [1]

Plot no.	Treatment of plot	Run-off	Erosion losses		Soil eroded per acre, per inch of run-off
			Soil lost per acre	Depth of soil lost	
		Inches	*Tons*	*Inches*	*Tons*
1	0 percent grade, planted to cotton	4.87	17.38	0.09	3.57
2	1 percent grade, planted to cotton	16.42	38.75	.20	2.36
3	2 percent grade, planted to cotton	17.85	54.14	.28	3.03
4	2 percent grade, fallow cultivated	26.59	77.46	.40	2.91
5	2 percent grade, fallow not cultivated	35.41	99.07	.51	2.80
6	2 percent grade, planted to grass	9.01	13.78	.07	1.53
7	2 percent grade, planted to milo	12.05	27.81	.14	2.31
8	3 percent grade, planted to cotton	[2] 15.20	[2] 53.37	.28	3.51

[1] These data were furnished by R. E. Dickson, superintendent of Texas substation no. 7 at Spur.
[2] Run-off and erosion disturbed by adding soil to build original grade.

	Inches rainfall
Rainfall for period:	
1926	38.08
1927	16.12
1928	19.99
1929	14.76
1930	18.60
1931	16.46
Average	20.67
21-year average	21.17

TABLE 9.—*Effect of slope of terrace on run-off and crop yields at Spur, Tex., 1927–31*

Year	Rainfall	Terraces with fall of 3 inches per 100 feet		Level terraces	
		Run-off	Yield of seed cotton per acre	Run-off	Yield of seed cotton per acre
	Inches	*Inches*	*Pounds*	*Inches*	*Pounds*
1927	16.12	0.56	553	0.11	611
1928	19.99	3.07	293	.86	467
1929	14.76	3.31	[1]	1.00	[1]
1930	18.60	2.12	88	.69	125
1931	16.64	.32	392	.09	513
Average	17.19	1.88	332	.55	429

[1] Cotton destroyed by hail in fall of 1929.

TABLE 10.—*Effect on crop yields of conserving water at Spur, Tex., 1927–31*

Year	Rainfall	Rows contoured (no terraces)		Rows with slope (slope 6 inches per 100 feet)		Diked to hold all water		Diked to hold all water and to receive water from other areas	
		Run-off	Yield of seed cotton per acre	Run-off	Yield of seed cotton per acre	Run-off	Yield of seed cotton per acre	Water added	Yield of seed cotton per acre
	Inches	*Inches*	*Pounds*	*Inches*	*Pounds*	*Inches*	*Pounds*	*Inches*	*Pounds*
1927	16.12	0.15	648	0.38	647	0	753	-------	-------
1928	19.99	3.73	301	2.88	157	0	587	-------	-------
1929	14.76	2.13	[1]	2.51	[1]	0	[1]	4.89	[1]
1930	18.60	.72	91	1.49	25	0	282	2.52	348
1931	16.46	.05	546	.36	504	0	618	.51	654
Average	17.19	1.36	397	1.52	333	0	560	2.64	-------

[1] Cotton destroyed by hail in fall of 1929.

The principal means being taken, on the High Plains, to check run-off and erosion, is that of contouring the rows of cultivated crops

FIGURE 7.—Cotton rows running down the slope on Amarillo soils in northeast Lubbock County. Rain water drains off rapidly and the crop may suffer from drought.

FIGURE 8.—Rows on contours. This field adjoins one shown in figure 7. Note difference in cotton, owing to better moisture conditions on contoured land.

(figs. 7 and 8). On the land which is almost level, this method has been found very efficient. On more sloping land, the contoured rows,

while holding the smaller rains and thereby proving very beneficial, will not always hold the harder, more intense rains which are common to the region. When the rows become filled with rain water, and break, gullies are formed and large amounts of soil and much needed water are lost. For this reason terracing is being recommended for the more sloping land. In 1929 only about 1.3 percent of the regional cultivated land had been terraced according to this survey. The percentage contoured was not determined, but it was obviously a great deal higher.

Where the land was effectively terraced it was found that water usually did not stand in the depressions, even after heavy rains. This made possible the cultivation of these very fertile spots, and thus many farmers are utilizing areas which formerly represented waste land. Production of vegetables has been very successful on some of these reclaimed depressions.

The fact that the pastures of the region are losing soil by washing is borne out by deep deposits of surface soil material in the depressions,

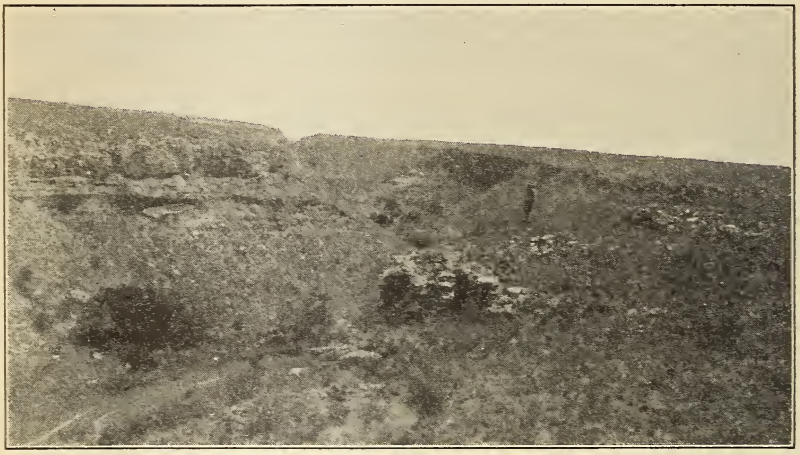


FIGURE 9.—Deep ravine cutting its way across the High Plains in southeastern Crosby County, Tex. Innumerable smaller ravines and gullies reach out laterally from these deep gorges.

and also by the reddish color of the water draining from the pastures during heavy rainfalls. The regional agricultural workers are recommending that some form of protection be given the sloping pasture lands. Terracing and the plowing of small back furrows or even single furrows at short intervals along the contours are practical to some extent as measures of pasture protection Proper stocking and rotation of pastures to avoid overgrazing is also looked upon as an effective means for checking sheet erosion, since a good stand of grass greatly retards the flow of water and holds the soil in place.

The eastern edge of the High Plains is marked in most places by a steep escarpment dropping off to the Rolling (or Eroded) Plains below. The escarpment zone is gradually extending back into the High Plains. Thousands of gullies and ravines are cutting their way into the fertile, level plains country, back of the escarpment as shown in figure 9. The Rolling Plains section (fig. 10) bears unmistakable evidence that it represents an eroded area which once was a continuation of the High Plains.

In the areas where the lighter soils occur, much damage is often done by wind erosion. In such places the damage results from (1) removal of soil by the wind, (2) deposition of wind-blown material, and (3) the abrasion or "burning" of crops by the sand-laden winds. The entire surface soil has been known to blow away in 1 year on land newly broken from the native prairie, leaving the comparatively unproductive subsoil exposed. On the other hand, the water furrows of bedded fields are often filled with wind-blown sand during a single sandstorm. Large areas of cotton occasionally must be replanted because of the killing or serious injury of the plants by the whipping and abrasion of wind.

The most practical effective means for preventing wind drifting of soil in this section on cultivated land, so far as observed, is to alternate strips of cotton with strips of some tall, thick-growing feed crop which will serve to protect the cotton or other susceptible crops from wind

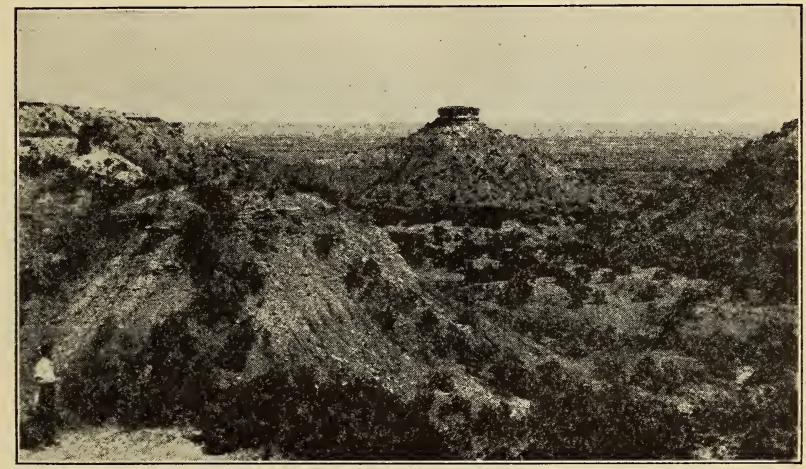


FIGURE 10.—Rolling Plains, showing mesas, remnants of the High Plains country which once extended far to the eastward. This shows the drastic change brought about by unchecked erosion. Such land is classed as rough broken land, and is suitable for pasture only. Southwest Garza County, just off the High Plains.

damage. These feed-crop strips are often planted so that they will run across the direction of the prevailing wind. The objection to this method is that the rows run down hill in places, thereby causing serious loss of water and soil. If the strips are planted on the contours they will give protection from the wind and also aid greatly in conserving soil and water. Feed strips planted on terrace lines have long been used effectively, in other regions to lessen run-off and erosion and to preserve the terrace lines until terraces can be constructed (fig. 11).

ROLLING PLAINS SECTION [7]

The counties and parts of counties included in the Rolling Plains section are Crosby, Garza, Borden, Dickens, Kent, Scurry, King, Stonewall, Fisher, Nolan, Knox, Baylor, Archer, Haskell, Throckmorton, Young, Jones, Shackelford, Stephens, Taylor, Callahan, and Eastland.

[7] Practically synonymous with the Red Plains of Texas and Oklahoma, a name which is coming into general use for this region.

SOILS OF THE SECTION

ABILENE-ROSCOE-FOARD GROUP

The Abilene-Roscoe-Foard group comprises the dark-colored soils of the Rolling Plains.

The Abilene soils are brown or chocolate brown in color and have deep, brown subsoils with an abundance of soft lime carbonate below. Except in color they correspond very closely to the Miles soils.

The Roscoe soils are dark brown to black, and are underlain by heavy, dark-brown or dark chocolate-brown subsoils with soft lime carbonate in the lower depths. They are the dark-colored correlatives of the Miles and Abilene series. The surface relief of the Roscoe soils is more nearly level.

The Foard soils are brown with rather dense clay subsoils of somewhat lighter color.

While these dark soils are not limy in the upper layers, they are underlain by a layer of accumulated carbonate of lime at a depth of several feet.

FIGURE 11.—Feed strips on prospective terrace lines make summer terracing possible and greatly lessen damage from water and wind erosion. Strips of sorgo (locally called "cane"), on contours, farm of Walter Davis, Bell County, Tex.

VERNON-ROUGH BROKEN LAND GROUP

The Vernon-rough broken land group consists of large bodies of Vernon soils associated with small and large areas of soils that have been so greatly washed and cut by erosion that they may no longer be considered of any possible use as arable land. These soils occur on the Red Beds formations and are often referred to as the Red Plains. The smoother areas and divides comprise considerable bodies of valuable soils of the Vernon series. These are red, calcareous soils which grade below into chocolate-red calcareous subsoils of heavier character than the topsoils. In many places the Vernon soils, unless protected, erode rapidly and are soon rendered valueless for profitable cultivation. The normal Vernon soils are inherently highly productive. The surface is undulating to rolling. The principal soils are sandy, but some good-sized areas of clay loam and clay also occur. The natural vegetation is mainly grasses, the short grasses and grama being abundant on the heavy soils, while grama and coarser bunch grasses prevail on the sandy types. In many places these soils have eroded to such an extent that their use, especially in this region of light rainfall, cannot produce profitable yields, and they may be termed submarginal land.

The rough broken lands range from smooth areas deeply grooved by many gullies, to steep, hilly lands and bare valley slopes, which have been carved by erosion into a typical badlands form. This land is of no value except for the pasturage of range livestock, but the protection it affords in winter, together with the fair growth of bunch grasses in the many narrow valleys gives it some value for cattle ranching, and it is used largely for this purpose.

MILES-VERNON GROUP

The Miles-Vernon group includes the red soils of the Rolling Plains section that do not fall into the Vernon-rough broken land group. The Miles soils occur in close association with Vernon soils, but occupy smoother positions. The surface soils are brown to brownish red in color, and are underlain by friable red subsoils. A well-developed layer of soft calcium carbonate has accumulated in the lower subsoil, but there is no carbonate of lime in the upper layers. The surface of the Miles soils is typically undulating to gently rolling, and the soils absorb water fairly readily, though on the steeper slopes, especially of the heavier types, there is considerable run-off and erosion. Less erosion occurs, however, than on the Vernon soils. Large areas of the Miles soils are of the sandy types, which are covered with a natural growth of coarse grasses, and in places shin oak. The heavier Miles soils, chiefly the clay loam, support a growth of grama grass, some buffalo grass, and other grasses.

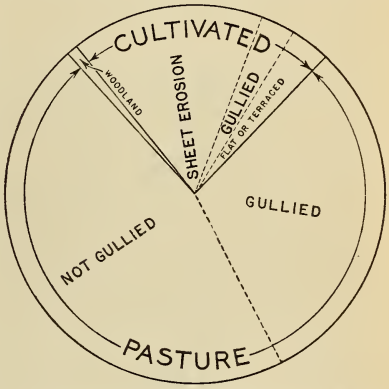


FIGURE 12.—Diagram showing extent of erosion in Rolling Plains section of watershed. Percentages are based on total area of section as follows: Cultivated land—sheet erosion 16.6, gullied 3.1, flat or terraced 3.3, total 23.0; pasture land—gullied 30.4, not gullied 45.7, total 76.1; woodland—gullied 0.05, not gullied 0.77, total 0.82.

The Vernon soils are red in color and characteristically limy. They grade beneath into red, moderately friable, limy clay or sandy clay. These soils are subject to very rapid erosion, and for this reason they constitute immature soils, that is, soils so unstable as not to permit the development of normal profile conditions, such as characterize the Miles soils. The principal types are the very fine sandy loam, fine sandy loam, clay loams, and clays. The surface is generally quite rolling with numerous steep slopes. Gullies and small valleys are of very common occurrence. Some areas of rough broken land have been developed from these soils. The native vegetation is principally grama grass, with some buffalo grass on the heavier types. Coarse grasses are found on the sandy soils.

EROSION IN THE ROLLING PLAINS SECTION

In sharp contrast to the High Plains, the drainage of the Rolling Plains is well developed, and a complete network of tributaries with their smaller branches, extends into every part of this section. The extent of erosion in this section is indicated by figure 12.

The topography of the Rolling Plains is quite varied. Approximately 10 percent of the cultivated land has so little fall that, to the eye, it appears practically level. Prior to the establishment of the erosion investigations at the Spur Experiment Station it was generally believed that this type of land was not suffering from erosion. The results of the measurements at Spur have shown conclusively that even level cultivated land loses considerable amounts of water and also suffers substantial soil losses when intense rains occur. Whenever water flows over the loosened surface it sweeps away some of the valuable topsoil. The Spur data (see table 8) show that for the 6-year period ended in 1931, with an average rainfall of only 20.67 inches a year, about 4 percent of the rainfall was lost by run-off from cotton plots which were level, and over 17 tons an acre of topsoil was washed away. On land having as little as 1 percent fall, which appears to the eye to be practically level, there was more than three times as great a water loss, and more than twice as much soil was carried away, as from level land.

Most of the cultivated land of the Rolling Plains section varies from gently undulating to quite rolling. Over 13 percent of all the cultivated land in the section is already gullied, according to this survey, and an additional 72 percent of sloping land is being gradually desurfaced by sheet washing. At the soil erosion experiment station located on similar land near Guthrie, Okla., cotton plots having a fall of 7.7 percent, on virgin Vernon fine sandy loam lost, during 1930, 16⅓ tons of soil to the acre. Fifteen and one third tons of this were lost in May, during which there was a total rainfall of 10 inches. Land which had the subsoil exposed lost at the rate of 35¼ tons of soil a year, 31½ tons of which were lost during the May rains.

Although the majority of the soils in the Rolling Plains section are of sandy porous character, they erode very rapidly during heavy rains. In general, the rougher areas are still being pastured. Where an attempt has been made to cultivate the more steeply sloping land, excessive erosion has usually taken place and the land has been abandoned. Seventy-six percent of the section is still uncropped, and 40 percent of this uncultivated land is gullied. The greater part of the remainder is suffering from varying degrees of sheet erosion. On many of the steeper slopes all the surface soil has been washed away, and even on the more nearly level areas large losses have occurred, especially during seasons when the land was overgrazed.

In the gullied pasture lands, the degree of gullying ranges from narrow, shallow washes, to a maze of deep steep-walled ravines which are often so numerous that much of the land is rendered almost worthless, even for pasturage. The extent of such damage is seen by the fact that in Dickens County 17.5 percent of all the land lying within the Brazos River watershed is classed as rough broken land. This is 23 percent of the pasture land, and an additional 11 percent is gullied less severely. In Kent County 8.4 percent of the watershed area is rough broken land; in King County, 5.8 percent; in Knox County, 6.9 percent; and in Garza County, 5.8 percent. The Rolling Plains section has a total of over 2,000,000 acres that have been damaged by gullying. Practically all the rough broken land in this region is due to erosion. Very little of it is stony or rocky in character (fig. 13).

There is no doubt that a great part of the erosion in pastures has been due to natural causes, and not to careless handling of the land by man. It is evident, nevertheless, that over most of the section too close grazing has caused both sheet washing and gullying to proceed much more rapidly than would otherwise have been the case. The extensive Croton Breaks in southeast Dickens County are caused, mainly, by the cutting back of lateral branches of Croton Creek, which has cut its bed far below the level of the surrounding country. Most of this land is pastured. In dry years, especially, the grass becomes very short and often appears practically dead. When rains come there is little to retard the water. Much less of the rainfall penetrates into the soil than if grass were there in abundance, and the water flows down the slopes much more rapidly than it otherwise would. This results in excessive erosion.

Many pastures which border roadways having deep side ditches (bar pits) have innumerable gullies leading back from the ditches

FIGURE 13.—An advancing ravine, about to cut through highway in Crosby County, Tex. Note vertical side walls at head of ravine and wide area being affected by laterals. Such eroded soils are classed as rough broken land.

into the fields for considerable distances. Where the road ditches are "young" the gullies are usually small and reach back only about 5 to 10 yards. A pasture bordering a new road was observed in Knox County, east of Benjamin, in which the gullies were very close together, and, although they penetrated into the field for only 8 to 10 yards, this strip of land was so badly dissected that it was unfit for any use whatever. In many places, as for example in Crosby, King, Kent, and Garza Counties, the lateral gullies have become practically as deep as the road ditch and have often eaten back into the pastures for 20 to 30 yards. In many places the road ditches have become very deep, thus causing the field ditches to become deeper, also. It is quite common for road ditches to become so wide and tortuous that the bordering fences are undermined, and topple into the gullies. It is not uncommon for the road itself to be destroyed. In the western part of the Rolling Plains there are many locations where roads frequently have to be changed, to make way for gullies which are reaching outward from nearby draws and ravines.

Careful selection of land for cultivation by the farmers of this section is evidenced by the fact that in Dickens County, for instance, only 1.6 percent of the cultivated land in the watershed is gullied. In the section as a whole, 13.6 percent of the cultivated land is gullied, and not yet protected by terraces. An additional 72.1 percent is subject to sheet erosion and needs protection by some means, such as contouring, terracing, or the growing of fibrous-rooted, erosion-resisting crops.

Considerable terracing and contouring has been done in this section. The terracing revealed by this survey in the various counties ranges from as low as 3 percent of the cultivated land, to around 19 percent. A considerable number of farmers in the more sandy areas employ strip cropping to check wind damage and many of these strips are planted on the contours so that erosion losses are also minimized.

EDWARDS PLATEAU SECTION

Only a small area belonging to the Edwards Plateau section occurs within the Brazos River watershed. This lies in central Nolan and Taylor Counties, adjoining the Rolling Plains section. Owing to the small area of this section included in the survey, it was not studied as a separate unit, and it is discussed, with the exception of its soils, in connection with the Rolling Plains section of the watershed.

SOILS OF THE SECTION

VALERA-ROUGH STONY LAND GROUP

The Valera-rough stony land group of soils includes more or less eroded areas of limestone lands, the smoother areas being occupied by the dark soils and included within the Valera series, whereas the eroded and broken bodies of associated limestone lands which are unsuited for cultivation are classed as rough stony land. The Valera soils are dark brown or black, with brown or yellowish subsoils. Most of the soils are calcareous, and shallow, often resting upon the unweathered limestone at depths of but a few inches. The principal soil is stony clay. The surface is undulating to gently rolling. The native vegetation consists of short grasses and various bunch grasses. However, on the stony soils many trees occur, consisting mainly of cedar, shin oak, live oak, redbud, and many shrubs, including catclaw, lote bush, agrito, and sumac. These shrubs and trees also occur abundantly on the rough stony land.

WEST CROSS TIMBERS SECTION AND ASSOCIATED PRAIRIES

The counties and parts of counties included in the West Cross Timbers section and associated prairies are Throckmorton, Young, Jack, Shackelford, Stephens, Palo Pinto, Parker, Callahan, Eastland, Erath, Hood, Brown, and Comanche.

SOILS OF THE SECTION

WINDTHORST-NIMROD GROUP

The Windthorst-Nimrod group of soils is predominant in the West Cross Timbers section. The Windthorst soils are brown or red in the surface soil and are underlain by rather heavy, red clay subsoils. They are generally shallow, and in many places rest on

sandstone. The fine sandy loam predominates, though in some areas erosion has been so severe that much stony material has been exposed, giving rise to large bodies of stony fine sandy loam. The surface relief is rolling, and erosion is severe wherever the soil is not protected. The principal vegetation consists of small oak trees, largely post oak. The less extensive Nimrod soils occupy the smoother positions and drainage divides of the West Cross Timbers section. They are gray in color with yellow subsoils. Occasional areas of dark-colored prairie soils appear in the western part of this section. Some rough stony land of both limestone and sandstone character occurs throughout the section. The vegetation is principally small oak.

EROSION IN THE WEST CROSS TIMBERS SECTION

The West Cross Timbers section of the watershed varies from undulating to steeply rolling and hilly, with occasional areas which are nearly level, especially on the broader divides. The drainage is well developed in all parts of the section. Erosion is severe in nearly every sloping field and over large areas all the soil has been washed away, leaving the underlying rock or stony parent material exposed. The extent of erosion in the entire section is shown in figure 14.

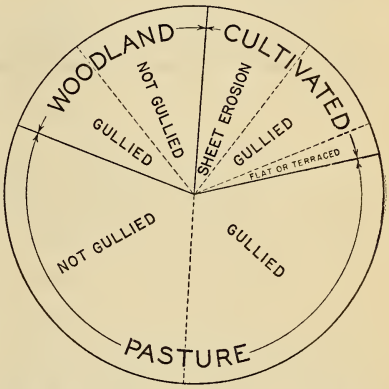


FIGURE 14.—Diagram showing extent of erosion in West Cross Timbers section of watershed. Percentages are based on total area of section as follows: Cultivated land—sheet erosion 9.1, gullied 8.4, flat or terraced 2.8, total 20.3; pasture land—gullied 29.4, not gullied 30.3, total 59.7; woodland—gullied 8.2, not gullied 11.8, total 20.

Only about 20.3 percent of this section of the watershed is in cultivation. Approximately 42 percent of this is gullied, and an additional 45.1 percent is suffering from sheet erosion. From 3 to 11 percent of the cultivated land in the various counties has been terraced. The terracing has been confined principally to the land that is already gullied, although all the land suffering from sheet erosion would be benefited by such protection. Pasture land comprises 59.7 percent of the section, and approximately half of this is gullied, owing chiefly to the rolling topography, but partly to the abundance of shallow soil overlying rock. The storage space for water is very restricted under such conditions, and the soil soon becomes saturated. Accordingly, during long or heavy rains, a large percentage of the water runs off. A larger proportion, both of cropped and uncropped land, in this section is gullied than in any other section of the Brazos River watershed. Most of the pasture land still ungullied slopes enough to suffer from sheet erosion. Large areas have already lost most or all of the topsoil, and support little useful vegetation.

Twenty percent of the section is classed as woodland, and about 41 percent of this land is appreciably gullied. The nature of the woodland varies considerably. Typically it supports such a dense growth of timber that there is little or no available pasture. In places the land is rough and stony, while in other locations there is

considerable grass in the scattered timber. Large areas of forested land are so hilly and stony that they are classed as rough stony land. Usually the forest growth on such areas consists principally of scrubby oak and cedar, with some mesquite on the less hilly areas. In the counties of Callahan, Eastland, Stephens, Young, Jack, Palo Pinto, and Erath the land classed as rough stony is practically all forested to a greater or less extent, is very rough and almost always stony. There are limited areas, however, where the stones do not occur or are very scarce. There are numerous locations where the forest growth consists almost entirely of small cedars. Such areas are known locally as cedar breaks. These have been classified according to the nature of the vegetation they support. Where the cedar growth is dense, and the land not excessively rough, it was classed as timberland. Where it is more open, and supports considerable grass, it has been included with pasture land. The greater part of such land, however, is rough and stony and therefore has been classed as rough stony land.

Although most of the rough stony land carries too little grass or is too rough to afford satisfactory pasturage for cattle, some of it is being utilized for goat pasture and large areas appear suitable for this purpose.

GRAND PRAIRIE SECTION

The counties and parts of counties included in the Grand Prairie section are Parker, Erath, Hood, Somervell, Johnson, Brown, Comanche, Hamilton, Bosque, Hill, Mills, Lampasas, Coryell, McLennan, Burnet, Bell, and Williamson.

SOILS OF THE SECTION

DENTON-SAN SABA GROUP

The Denton-San Saba group comprises the principal soils of the Grand Prairie, a large prairie area underlain by hard limestone. These soils are all dark in color, except where erosion has removed much of the surface material, exposing limestone and interbedded layers of marl material. The soils of this group are almost entirely of the clay and stony clay types. The Denton soils have brown topsoils, underlain by lighter-brown or yellow subsoils which rest on hard limestone or the associated marl. They are shallow in many places with numerous areas of stony land on the steeper slopes. The surface relief varies from very gently rolling to rolling. The San Saba soils have black or very dark brown surface soils and subsoils of somewhat lighter colored clay, which rests directly on limestone. These are the deepest soils of the group, and the most nearly flat.

These prairie soils usually are covered in the uncultivated areas with coarse grasses. Short grasses predominate in some places. Associated with the prairies are considerable areas of rough stony land. These and the rougher areas of prairie soils carry in many places a considerable growth of various small oaks and junipers. This small tree vegetation has encroached upon the deeper and smoother soils in numerous localities since occupation of the region by white men. Where the juniper predominates, the land is styled cedar breaks.

EROSION IN THE GRAND PRAIRIE SECTION

The relief of the Grand Prairie varies from undulating to steeply rolling and hilly. There is little flatland, except the alluvial plains along streams. Large areas are so rough and stony as to have little agricultural value. Most of these rough lands are covered with a light growth of timber and underbrush; some of them furnish considerable pasturage to goats and other livestock. Since the soils are mostly clays and are shallow, resting on hard limestone, they have very low water-holding capacity. Furthermore, rain water penetrates into these heavy soils slowly, so that during hard rains run-off and erosion are severe. The extent and kinds of erosion in the Grand Prairie section are shown in figure 15.

Nearly 32 percent of the section is in cultivation. Approximately 61 percent of this cultivated land is suffering from sheet erosion and 28.9 percent is gullied. Pasture land comprises 47.8 percent of the section. This includes large areas of rough stony land, often quite thickly covered with scrub oak, juniper, and other trees. Of the land classed as pasture, 41.4 percent is gullied. This high percentage of gullying is due largely to the very rough nature of the surface and to the shallowness and heavy character of the soil.

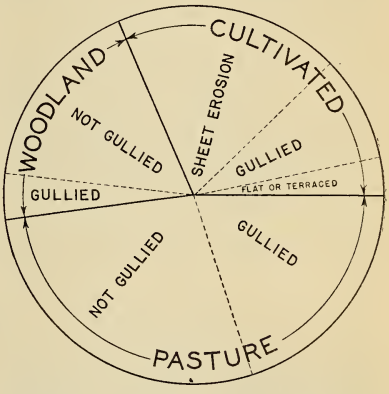


FIGURE 15.—Diagram showing extent of erosion in Grand Prairie section of watershed. Percentages are based on total area of section as follows: Cultivated land—sheet erosion 19.2, gullied 9.1, flat or terraced 3.3, total 31.6; pasture land—gullied 19.8, not gullied 28, total 47.8; woodland—gullied 3.9, not gullied 16.7, total 20.6.

Woodland covers 20.6 percent of the section and is quite rough in many places, affording very little pasturage. Of this class 19 percent is gullied.

Little terracing has been done throughout the section as a whole. In some localities the terraces are not being cultivated, but have been allowed to grow up to brush, weeds, and grasses. On the steeper slopes, where it is difficult to maintain terraces, such a practice may have merit, but it generally has been deemed undesirable.

BLACKLAND PRAIRIE SECTION

The counties and parts of counties in the Blackland Prairie section are Hill, McLennan, Limestone, Bell, Falls, Robertson, Williamson, Milam, Lee, Burleson, Brazos, Grimes, Bastrop, Fayette, Washington, and Austin.

SOILS OF THE SECTION

HOUSTON-WILSON GROUP

In the Houston-Wilson group, the Houston soils have brown to black calcareous surface soils overlying lighter-brown, yellow, or cream-yellow limy subsoils, which grade below into chalk or marl. The clay types are largely predominant. They are granular when dry, and can be easily maintained in a friable condition under cultivation. The clay is extremely heavy and very sticky when wet.

This sticky, plastic character has given rise to the common name "black waxy land." The Houston soils make up about four fifths of the Blackland Prairie (the Black Belt). The surface is gently undulating to rolling. The soils and subsoils are permeable and allow fairly rapid passage of water downward. Erosion, especially sheet washing, is severe wherever the soil is unprotected. The native vegetation consists mainly of coarse grasses, such as the big and little bluestems, together with some grama and buffalo grasses and small mesquite trees. Following excessive erosion, however, weeds appear in a much larger proportion, and there is usually a much greater area of bare surface.[8] This is also true, to a great extent, of the other soils discussed in this report, following erosion and abandonment.

The surface soils of the Wilson series are very dark gray to nearly black. In this respect they closely resemble the Houston, although they are not quite so dark, having a grayish surface cast on drying. The subsoils are dark gray to yellowish, grading beneath into calcareous beds. Neither the surface nor the subsoil is calcareous, although limy material is usually present at lower depths, and limy spots are present in places through the areas of Wilson soils. The soils are characteristically dense, drying out to a very hard, tough condition which causes difficulty in cultivation. As a rule the Wilson soils occupy less sloping positions than the Houston, although some areas are sufficiently steep to favor erosion and even the formation of gullies. The native vegetation is predominantly of the coarse grass type, together with frequent thickets of mesquite trees.

WILSON-CROCKETT GROUP

In certain areas the Wilson soils are associated mainly with noncalcareous dark soils which are of the Crockett series. These dark soils somewhat resemble the Houston in the surface soil, but are not calcareous and are not so friable, although they are more friable than the Wilson soils. The subsoils are mainly of mottled clays, or, in places, of red or yellow clays, and are not calcareous. In places fine sandy loam occurs, which is of lighter color than the heavier types. These soils are generally of limited extent, and in many places occur as transitional areas between typical blackland soils, such as the Houston-Wilson group, and the timbered sandy soils of the East Texas timber country.

EROSION IN THE BLACKLAND PRAIRIE SECTION

The Blackland Prairie section ranges in surface configuration from gently undulating to steeply rolling. Level land occurs only along the stream bottoms, although occasional upland areas are decidedly flat and very nearly level. Approximately 61.5 percent of the land is in cultivation, 10.8 percent in woodland, and 27.7 percent is being pastured. Erosion is severe throughout the entire section, and 38.3 percent of the cultivated land is gullied, according to the results of this survey. An additional 59.4 percent is suffering from sheet erosion. Figure 16 indicates the extent and kinds of erosion in the Blackland Prairie section.

On some of the nearly level areas where the native vegetation has never been disturbed, and where the land has not been overgrazed,

[8] BENNETT, H. H. RELATION OF EROSION TO VEGETATIVE CHANGES. Sci. Mo. 35: 385–415, illus. 1932.

very little soil appears to have been lost by erosion. In such places the black soil often extends to depths ranging from 18 inches to nearly 3 feet. This indicates that a thick mantle of fertile black soil originally occurred over the more nearly level parts of the Blackland section. Remaining areas of unplowed prairies of the Houston black clay type indicate that the average depth of the original black true surface layer for the rolling part of the Black Belt was probably between 12 and 15 inches (figs. 17 and 18).

In the 40 to 60 years during which most of the cropped land has been under cultivation much of the black topsoil has been washed away in many fields, and in places, especially in the western part of the Blackland Prairie where underlain by chalk, many farm-land slopes are entirely denuded of topsoil, and in some, even the subsoil has also been carried away, leaving the raw chalk or marl exposed. As the layer of black soil becomes thinner, or vanishes entirely the crop yields decrease. Formerly it was not uncommon to produce three fourths of a bale of cotton to the acre. On areas where the whitish underlying material is exposed, crops are frequently a complete failure, especially in dry years; and the average production for the whole Blackland belt has dwindled to less than one third of a bale an acre (fig. 19).[9] The principal cause of this decrease in crop yields is clearly evidenced by the map in figure 20 which shows the extent and varying degrees of erosion on a typical Blackland farm.

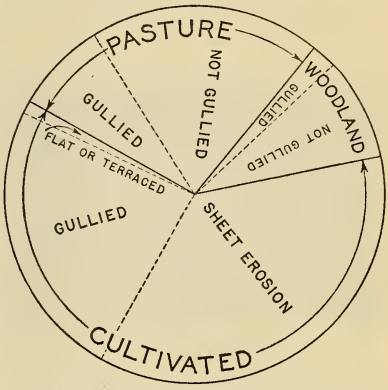


FIGURE 16.—Diagram showing extent of erosion in Blackland Prairie section of watershed. Percentages are based on total area of section as follows: Cultivated land—sheet erosion 36.6, gullied 23.6, flat or terraced 1.3, total 61.5; pasture land—gullied 7.8, not gullied 19.9, total 27.7: woodland—gullied 2, not gullied 8.8, total 10.8.

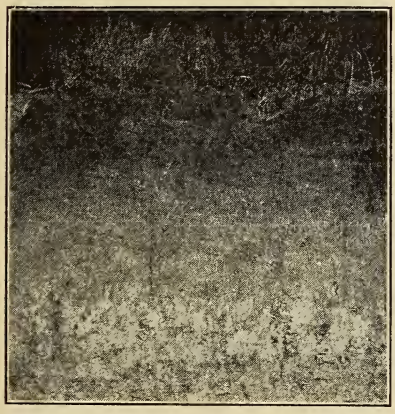


FIGURE 17.—Uneroded Blackland Prairie soil. The chalky parent material here lies at a depth ranging from 2 to 3 feet. This area of Houston black clay in Bell County, Tex., has never been plowed nor seriously overgrazed.

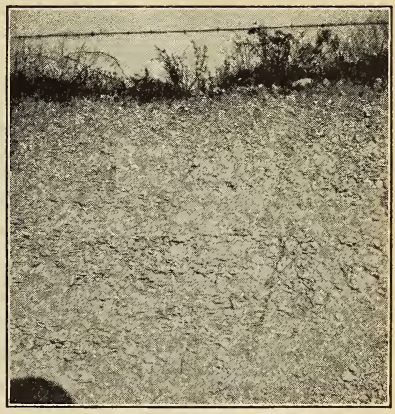


FIGURE 18.—Badly eroded Blackland Prairie soil, with dark surface and subsurface material entirely washed away, leaving chalky substratum exposed. This area has never been plowed but has been badly overgrazed.

[9] Data compiled by Henry Dunlavy, superintendent of substation no. 5, of the Texas Agricultural Experiment Station.

These prairies are subject to very intense rains. During such rains the losses of water and soil are tremendous. At the Blackland Erosion Station at Temple, Tex., cotton plots having a 4 percent fall, lost soil at the rate of 23 tons an acre during a 5½-inch rain in May 1930, and over 95 percent of the rain water ran off. In May 1932, a 1-inch rain swept away more than 10 tons of soil per acre from corn plots on the same degree of slope. The value of fibrous-rooted crops was demonstrated during this latter rain, as oat plots and grass plots on the same slope lost neither soil nor water. Where strips of oats or sorghum were planted across the slope at intervals, on the contours, some water was lost but no appreciable amount of soil.

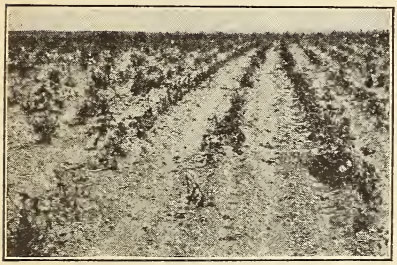


FIGURE 19.—Cotton on badly eroded soil, Sumter clay, which was formerly Houston black clay, near Eddy, McLennan County, Tex. The chalky substratum is now exposed. The crop is nearly a complete failure. These soils are droughty and very infertile.

Native pastures that have not been too closely grazed have lost very little soil, where the land is not very sloping. However, large areas throughout the belt have been so heavily pastured that very little vegetation is left to prevent washing; and here sheet erosion has removed all of the dark-colored surface soil, leaving exposed the light-colored substratum which is very low in productivity.

FIGURE 21.—Native vegetation on uneroded Blackland Prairie soil. The vegetation consists mainly of good pasture grasses. There are few weeds and very little bare ground. Houston black clay near Temple, Tex.

Where pasture land has been severely eroded, a drastic change in the type of vegetation has resulted. The better pasture grasses have largely or completely disappeared, being replaced partly by weeds, with much of the ground left bare, as stated above. Considerable areas once cultivated have been so badly eroded and consequently become so unproductive that they have been abandoned or turned over to pasture. Under these conditions the reestablished vegetation is even

LEGEND - SOIL LOSSES

	INCHES SOIL LOST	TOTAL AREA ACRES	TONS SOIL LOST
①	0	82.36	--
②	2 - 5	12.55	6 589
③	6 - 11	10.04	12 801
④	12 - 17	19.39	42 173
⑤	18 - 23	10.49	32 257
⑥	24 - 35	19.59	86 686
⑦	36 - 42	1.83	10 706
	TOTALS	136.25	191 212

AREA HAVING NET SOIL LOSS - 73.89 ACRES
AVERAGE LOSS PER ACRE - - 2588 TONS
AVERAGE INCHES SOIL LOST - 17.25

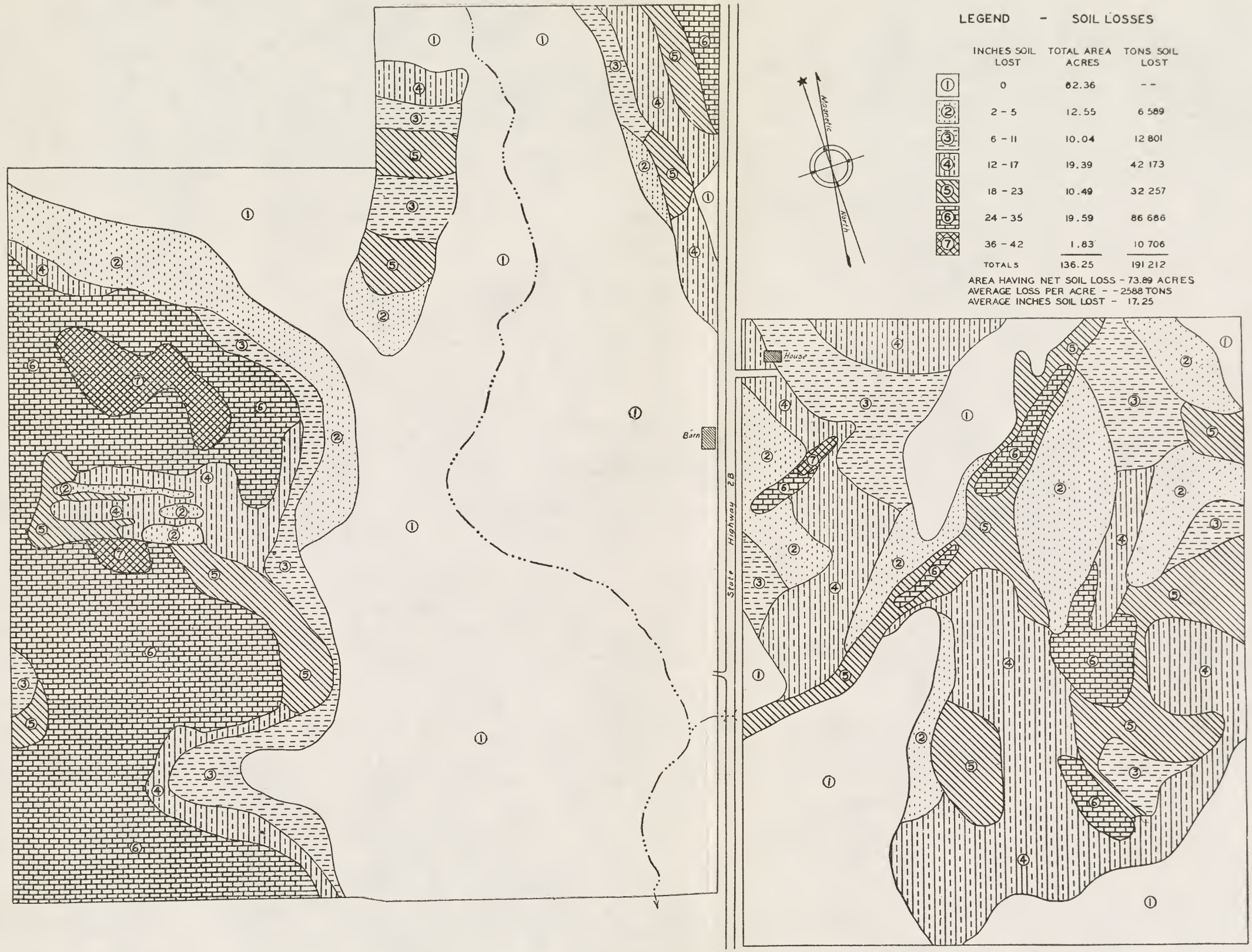


FIGURE 20.—Showing amounts of soil lost by erosion from typical Blackland farm.

more different from the original than where the erosion has resulted entirely from overgrazing (figs. 21 and 22). Numerous determinations have been made of the species of vegetation occurring under these different conditions, together with the proportion of ground surface covered by each. The results of some of these surveys are given in table 11.

Considerable gullying has taken place also on the pasture lands of the Black Belt, 28.3 percent of all pasture land having been found suffering from this type of erosion. Even 18.8 percent of the woodland has been gullied. These areas are found chiefly on the more rolling land near the edges of the belt, bordering the rougher Grand

FIGURE 22.—Vegetation on badly eroded soil of Blackland Prairie section. There is a large proportion of bare ground, and the vegetation is mostly weeds. This field adjoins that in figure 21.

Prairie section and on the smooth alluvial soils along draws and streams.

Very little has been done to protect the soils of the Blackland Prairie section from erosion. The common custom is to run crop rows up and down the slopes, wherever possible. There has been comparatively little terracing accomplished. Practically no pasture land has received any artificial protection from erosion.

Cotton is the principal crop. On numerous farms it occupies the same land for many years in succession. The experiment station at Temple has shown conclusively that this practice greatly encourages erosion, while it has been shown at the same station that crop

TABLE 11.—*Proportion of bare surface, and of area occupied by grasses and weeds for various conditions of erosion in the Blackland Prairie section*

Field no.	Slope	Soil type	Condition with respect to erosion	Field treatment	Bare ground	Vegetation [1] (estimated proportion)	
						Useful grasses	Weeds
	Percent				*Percent*	*Percent*	*Percent*
1	2–3	Houston black clay	No gullies, moderate sheet erosion.	Native prairie grasses cut for hay; not pastured, never plowed.	6	98.9 (8 species)	1.1 (7 species).
2	4	Houston clay, shallow phase	Severe sheet erosion, with few gullies.	Native prairie grasses pastured closely, never plowed.	35	9.2 (buffalo grass)	90.8 (12 species).
3	6–7	Sumter clay (original Houston black clay surface entirely removed by erosion.)	Severe sheet erosion, with some deep gullies.	Formerly cultivated, now abandoned; not plowed for 4 years.	60	2.5 (beardgrass)	97.5 (6 species).
4	4–6	Houston clay, shallow phase	Sheet erosion pronounced, with some shallow gullies.	Formerly cultivated, abandoned for 3 or 4 years.	60	67.5 (4 species; 62.5 percent Bermuda grass).	32.5 (10 species).
5	2	Houston black clay	No visible sheet erosion, no gullies.	Native prairie, never plowed nor overgrazed.	6	96.8 (8 species)	3.2 (15 species).
6	3–8	Sumter clay	Sheet erosion very severe, some deep gullies.	Cultivated 31 years, then abandoned 9 years; neither plowed nor pastured for 9 years.	25	84 (5 species) [2]	16 (16 species).
7	3	Houston black clay	No perceptible erosion; no gullies.	Native prairie grasses cut for hay, pastured lightly.	5	91.6 (7 species)	8.4 (10 species).
8	4	Sumter clay (subsoil of Houston black clay).	Severe sheet erosion; no gullies.	Formerly cultivated, abandoned 4 years.	75	0	100 (11 species).
						Proportions determined by air-dry weight	
						Grasses	Weeds
						Percent	*Percent*
9	3	Houston black clay	Slight sheet erosion, no gullies.	Native prairie cut for hay; pastured lightly, never plowed.	5	94.6 (2,335 pounds per acre).	5.4 (132 pounds per acre).
10	3	Sumter clay	Severe sheet erosion; with some gullies.	Native prairie; overgrazed; never plowed.	70	37.5 (191 pounds per acre)	62.5 (319 pounds per acre).
11	4	do	Severe sheet erosion; no gullies.	Native prairie; overgrazed	75	32 (116 pounds per acre)	68 (247 pounds per acre).
12	5	do	do	do	65	10.9 (70 pounds per acre)	89.1 (571 pounds per acre).

[1] Plants identified by Simon E. Wolff, botanist, Texas Agricultural Experiment Station.

[2] These results seem to indicate that on abandoned eroded land, not pastured, plowed, or burned, useful grasses will slowly become reestablished, over a considerable part of the denuded soil at any rate. Johnson and Bermuda grass will spread over such areas much more rapidly than the grasses of the original stand.

rotations, including fibrous-rooted crops, decidedly lessen erosion.[10] Had all the crop land in this once highly fertile section been protected

FIGURE 23.—This well-built, broad-base Mangum terrace protects the land from gullying. Farm machinery can be operated over such terraces with very little inconvienence. Central Bell County, Tex. Houston black clay.

from erosion at the time it was first put into cultivation, much of its virgin fertility would still be retained (figs. 23 and 24).

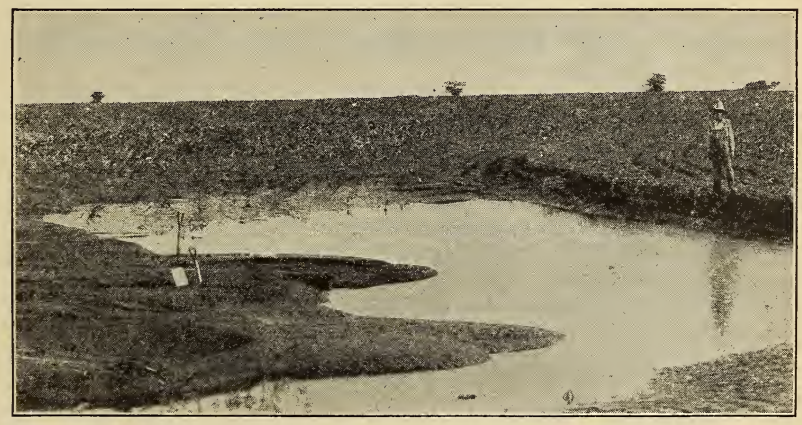


FIGURE 24.—During a 5½-inch rain in May 1930, this terrace on the Blackland erosion farm at Temple saved a large amount of soil which would otherwise have been washed from the field.

EAST TEXAS TIMBER COUNTRY SECTION [11]

The counties and parts of counties included in the East Texas Timber Country section are Johnson, Hill, Limestone, Freestone, Falls, Robertson, Leon, Madison, Williamson, Milam, Burleson, Brazos, Grimes, Lee, Washington, Bastrop, Fayette, Austin, and Waller.

[10] Unpublished progress report of Blackland Erosion Station for 1933.
[11] Includes parts of the East cross timber section.

SOILS OF THE SECTION

KIRVIN-NORFOLK GROUP

The Kirvin soils are brownish gray to slightly reddish, with rather heavy, red clay subsoils, which are moderately permeable to water. The sandy types predominate. The surface is undulating to hilly, and run-off is fairly rapid. These soils are acid in reaction. The Norfolk soils are gray, with yellow subsurface material, merging into friable yellow sandy subsoils. These soils also have an acid reaction, and the sandy types predominate. The surface is undulating to hilly, and the drainage is good. The deeper sandy areas are not erosive in a spectacular sense; nevertheless they suffer from sheet washing and even from gullying under certain conditions.

The native vegetation of the more rolling areas of this group of soils consists principally of small oaks, with post oak, red oak, and some others predominating, while post oak, water oak, willow oak, and sweetgum characterize the more poorly drained flats.

LUFKIN-SUSQUEHANNA GROUP

The Lufkin soils are gray at the surface with dense, heavy impermeable clay grayish or ash-colored subsoils. Throughout the profile the reaction is acid. The fine sandy loam predominates, although throughout its occurrence it is intimately associated with other types of this and other closely related series. The surface varies from flat to undulating. Owing to lack of effective pore space in the subsoil the level areas are very poorly drained. The underdrainage is imperfect everywhere. Water-loving trees, chiefly pin oak (willow oak) are characteristically present on the level areas, such as are commonly styled "pin-oak flats", but post oak predominates over most areas that are not depressed.

The Susquehanna soils are light brown or gray in color for a few inches, merging into a subsurface of mottled yellow, which rests upon a subsoil of very dense, heavy clay, mottled red and gray. In places these soils are very shallow, and the parent material of dense red or gray, or mottled clays or clay shales, lies near the surface on the more sloping land, and is often exposed on steeper areas. These soils, when unprotected, are very erosive, and on the sloping cultivated land gullying is common and often very severe. The soil reaction is acid. The surface configuration and the native vegetation are similar to the Kirvin-Norfolk group.

EROSION IN THE EAST TEXAS TIMBER COUNTRY SECTION

The East Texas Timber Country is mostly undulating to gently rolling, although there are numerous comparatively smooth areas that are nearly level. Most of the soils are of a sandy nature. These soils wash considerably, especially when the sandy layer is shallow and the slope steep; but once gullies have cut through the surface layer, erosion takes place at a dangerously rapid rate. Ravines 10 or even 20 feet or more in depth are not uncommon within 30 yards from where the gullies head. This is especially true on the Susquehanna and Kirvin soils, which are the most erosive soils of the section. The Lufkin soils gully badly also where they have much slope. They occur for the most part, however, on nearly level land, and accordingly do not wash nearly so severely as the Susquehanna and Kirvin

soils (fig. 25). The extent and kinds of erosion in the section of East Texas timber country included in the watershed are shown in figure 26.

In Robertson County, about 4 miles north of Franklin, it has been necessary to move a public highway, at frequent intervals, owing to

FIGURE 25.—This road ditch has attained the proportions of a small canyon, and tremendous lateral gullies are cutting back into bordering fields. Susquehanna fine sandy loam. Robertson County, Tex.

the rapid advance of a gully which is from 10 to 20 feet deep. Branches of this gully ramify in all directions and have destroyed a considerable area of land. The slope at this location is not great, but the land stands well above the level of the main streams of the section, so that the tendency of all gullies is to cut their beds to the level of the channels of the nearby streams.

On the more nearly level land, where but little erosion has taken place, the sandy surface and subsurface layers of soil are still about 15 to 20 inches deep. Sheet erosion is very severe, however, on the more sloping areas, especially of the Susquehanna and Kirvin soils, even where they are of a sandy nature. Clay spots, representing erosion-exposed subsoil, are a characteristic of nearly all sloping fields of these types which have been in cultivation for a generation or longer.

FIGURE 26.—Diagram showing extent of erosion in East Texas timber country section of watershed. Percentages are based on total area of section as follows: Cultivated land—sheet erosion 20.8, gullied 6.8, flat or terraced 3.8, total 31.4; pasture land—gullied 8.8, not gullied 24.3, total 33.1; woodland—gullied 5.1, not gullied 30.4, total 35.5.

Only a small part of the land in the section has been terraced. Already large areas have been so badly gullied that they cannot be reclaimed for farming upon any practical basis. In many places where terraces have been given too much fall, or where the terrace

outlet was left unprotected the terrace channel has become a bad gully, in places even a deep ravine (fig. 27).

It is evident that more experimentation is necessary to determine the best methods of land protection for this, as well as other parts of the Brazos watershed. The Soil Erosion Experiment Station near Tyler, located on soils common to the East Texas Timber Country, is making an intensive study of the erosion problems of the area, and is also determining the most practicable types of vegetation which may be grown there for pastures. Good pasture covers greatly lessen erosion, and it seems highly desirable that more of the sloping land of this section be devoted to the livestock industry in order that the soils may be given necessary protection, not only for those now farming them but for future generations.

A little over 31 percent of that part of the East Texas Timber section comprised within the Brazos watershed is in cultivation. Of this, 21.7 percent is gullied, and 66.2 percent additional is suffer-

FIGURE 27.—This terrace emptied into a deep road ditch. The outlet was not protected and the terrace channel has cut to the depth of the road ditch. Susquehanna fine sandy loam in eastern Robertson County, Tex.

ing from sheet erosion. Approximately 33 percent of the total area has been classed as pasture land. Nearly 27 percent of the latter is gullied. More cultivated land has been abandoned there than in any other part of the watershed. This has been owing largely to sheet erosion, although gullying has played an important part in rendering large areas practically worthless as crop land. Where gullies were not in evidence the abandoned land was included under the classification "pasture, not gullied." In order to have determined whether or not this pasture land had been cultivated, it would have been necessary to examine each pasture more closely than time permitted. It is generally claimed, locally, that all the pasture land in this section from which the timber has been cleared was at one time cropped. If this is true, it is still possible, of course, that a considerable part of the land now being pastured was taken

out of cultivation for reasons other than excessive erosion. Nevertheless, the pasturing of over a million acres of land in this part of the watershed is impressive evidence that erosion has taken a tremendous toll of the agricultural resources of the section (fig. 28).

About 35.5 percent of the East Texas Timber Country is still forested. Of this, 14.4 percent is gullied. Trees, underbrush, and the layer of partially decomposed vegetal material which usually covers the floor of a forest, when it is not repeatedly burned, all serve to check erosion. It is obvious that any timbered land of the section which is so sloping or so erosive that gullies develop rapidly under cultivation, should never be cleared except for permanent pasture.

COAST PRAIRIE SECTION

The counties and parts of counties in the Coast Prairie section are Austin, Waller, Fort Bend, and Brazoria.

FIGURE 28.—Sloping pasture lands erode badly when overgrazed or when water follows a cow path or wagon track down a slope. Pastures that are sloping enough to erode should be terraced or contour furrowed to prevent washing, and to save valuable rain water.

SOILS OF THE SECTION

HOCKLEY-KATY GROUP

The soils of the Hockley-Katy group consist mainly of fine sandy loams. They occupy a broad belt at the northern edge of the flat coastal region known as the coastal prairie.

The Hockley soils have light-brown topsoils of which the surface layers are underlain sharply by dense heavy yellow and gray mottled clay. Although the surface is undulating, the natural drainage is slow. The native vegetation consists of heavy coarse grasses.

The soils of the Katy series have brown topsoils and heavy clay subsoils, usually mottled gray, yellow, rust brown, and red. The surface relief is flat to gently undulating. The natural drainage is very slow, owing both to the flat relief and the impervious nature of the subsoil. The native vegetation consists chiefly of a rather heavy growth of coarse grasses.

LAKE CHARLES-EDNA GROUP

The Lake Charles soils are the predominant soils of the Gulf Coast prairie country. These are very dark gray to black soils, underlain by heavy clay subsoils of somewhat lighter color, which at several feet grade into light-colored marl. Clay is the principal type. The surface is characteristically flat, though in places very gently sloping. Surface drainage is very slow. The native vegetation consists principally of coarse grasses, *Andropogon* and others.

Associated with the Lake Charles soils are many small areas of the Edna series. These are gray soils with very dense, plastic, grayish, clay subsoils. They occupy flat or depressed areas, and water stands on them for long periods. The original vegetation is of a water-loving character, consisting of coarse grasses and a variety of weeds.

HARRIS GROUP

The Harris soils are marshy or semimarshy, and saline in character. They grade into true tidal marsh immediately bordering the Gulf of Mexico. The soil is gray in the upper part, and gray to dark gray below. The surface is essentially level, and the drainage very poor. Owing to their low position, the water table stands close to the surface, and during considerable periods is actually at the surface of these soils. The natural vegetation consists of water-loving grasses and sedges, with much of the coarse grass known as salt grass.

EROSION IN THE COAST PRAIRIE SECTION

With the exception of a narrow belt along the northern border of the section, which is gently undulating, the surface relief of this coastal area is more level than any of the other sections of the Brazos watershed. About 23.3 percent of the coastal area is in cultivation, but only 0.4 percent of this is gullied. Sheet erosion is affecting about 35 percent of the cultivated land, but, due to the level character of the land, such washing is rarely severe. The rainfall is higher than that of any other part of the watershed, averaging 42.84 inches annually. Rains of high intensity are quite common. The natural waterways, consisting largely of shallow, winding bayous, are unable to carry away the excess of these downpours. As a result, the water flows across the surface, and in so doing carries off considerable topsoil from some locations.

The greater part of the section is used as pasture land. Only about 2 percent of this is gullied. The gullied land is largely restricted to the more undulating Hockley soils in the northern part of the section. Gullying is not serious at any place.

Some terracing has been done. No doubt large areas of the Hockley soils would be benefited by such protection.

About 14.4 percent of the area is timbered. The greater part of this is comprised in the Brazos River bottoms, although there is a scattering growth of scrubby timber over strips bordering most of the drainageways. There is very little gullying in the timbered land, only 3.1 percent being recorded in this survey.

The extent and kinds of erosion in the Coast Prairie section are shown in figure 29.

ALLUVIAL SOILS OF THE BRAZOS RIVER WATERSHED

Since the alluvial soils are widely distributed throughout the watershed, they cannot be considered as a regional unit, but the more important are briefly discussed below. They are of the Miller, Yahola, Trinity, Catalpa, Pledger, and Ochlockonee series. These alluvial soils occur over the first bottoms and are subject to overflow during periods of flood. There are strips of older alluvial soils which, because of their present position above overflow, or second-bottom positions, have been included with the uplands for the purposes of this survey. The Miller soils have chocolate-red, calcareous surface soils, and subsoils which are similar in color and lime content but are usually of heavier texture. The Yahola soils differ from the Miller only in having the lower part of the 3-foot profile lighter textured than the upper subsoil. This coarser lower stratum usually consists of silt or sand, whereas the upper subsoil generally consists of clay or silty clay. The soils of both series are composed of material which has been washed largely from the Vernon soils in the Red Plains of Texas. They occupy both narrow and wide strips of bottom land. Aside from occasional overflows the drainage is fairly good.

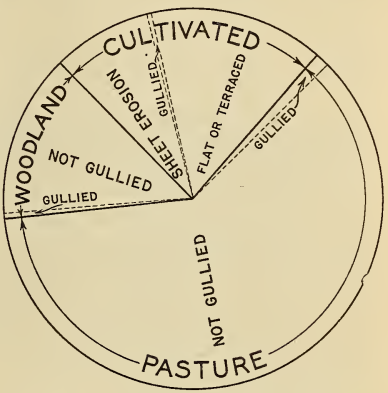


FIGURE 29.—Diagram showing extent of erosion in Coast Prairie section of watershed. Percentages are based on total area of section as follows: Cultivated land—sheet erosion 8.2, gullied 0.1, flat or terraced 15, total 23.3; pasture land—gullied 1.3, not gullied 61, total 62.3; woodland—gullied 0.5, not gullied 13.9, total 14.4.

The Trinity soils are black, rich in lime and organic matter, and overlie dark-gray to ash-gray limy subsoils. They occur in stream bottoms draining the Black Belt section, that is, the section of Houston soils. The clay is the most important type. It is very sticky when wet, but, like the Houston, crumbles to a desirable granular condition on drying. The Catalpa soils differ from the Trinity only in their lighter color. The Pledger soils are also dark, limy soils, but are underlain by red, limy subsoils. They are composed largely of sediments derived from the upland soils of both the Black Belt and the Red Plains.

The Ochlockonee soils are brown or light brown in the upper part, and light brown or yellowish beneath, with considerable gray mottling. They are composed of sediment washed largely from the soils of the East Texas Timber Country. They are acid and poorly drained. Large areas remain in a very wet condition for long periods. Overflows are rather frequent and often prolonged.

The alluvial soils of the Brazos River watershed were all covered, originally, with a heavy timber growth. A large proportion of the Ochlockonee, and occasional good-sized areas of the other soils are still forested. On the Miller and Yahola soils the original stands, of which a partial growth remains in occasional forested areas, included

chiefly hackberry, oak, pecan, and elm. The Trinity, Catalpa, and Pledger soils supported chiefly elm, ash, hackberry, and oak. The forests on the Ochlockonee included chiefly water oak, willow oak, ash, hickory, holly, and ironwood.

GENERAL DISCUSSION OF THE BRAZOS RIVER WATERSHED AREA

The tremendous extent to which soil erosion has progressed in Texas is revealed by the data obtained in this reconnaissance erosion survey. From the eastern edge of the High Plains to the northern boundary of the Coast Prairie, the havoc being wrought by uncontrolled run-off rain water is evident almost everywhere. Most of the cropped land has been farmed for only about 60 years, and for a much shorter period in numerous instances; yet in this comparatively short time yields have decreased until they now range from about one half to less than one tenth of what they originally were in almost countless fields. This costly impoverishment of the soil, as pointed out above, has been caused mainly by the washing away of the fertile topsoil. Once this is gone, it is a long, laborious, and costly process to rebuild on the exposed sublayers, soil having anything like the original productivity and mellowness. In fact, about all that can be accomplished is to preserve what is left. On well-terraced land and land otherwise adequately protected, productive soil can be recreated with the aid of manures, soil-improving crops, and fertilizers. Farmers working unprotected soils are complaining that with each succeeding year it is becoming more and more difficult to make a living on the land. It is only in recent years that they have begun to realize the extent to which erosion has been responsible for soil impoverishment, and even today only a very small proportion of farmers are taking steps to check this greatest of menaces to successful crop production.

SOIL LOSSES FROM WATERSHED

The Brazos River, at its mouth, has an average discharge of about 8,000 cubic feet a second.[12] This amount corresponds to approximately 69,500,000 acre-inches of water a year.[13] From unpublished data collected at the various soil-erosion experiment stations located in this watershed, and on comparable land, it is safe to assume that for each acre-inch of run-off, at least 1.5 tons of soil are washed from the lands of the watershed by sheet erosion alone. This means a minimum loss of 104,250,000 tons of soil a year. It should be observed in this connection that this loss refers to soil removed from its point of origin. Not all of this goes directly into the streams. The greater part is temporarily lodged on lower slopes, where it usually gives no benefit to, or even injures the land covered. Part is deposited over alluvial plains and in depressions en route to the streams.

Based upon further data obtained at the erosion stations, and upon observations made throughout the watershed, it may safely be assumed that at least 80 percent of this eroded soil is washed from the

[12] See footnote 1, p. 3.

[13] The total run-off from the lands of the watershed is much greater than this amount, since the discharge at the mouth of the river does not take into consideration the large volume of water that is absorbed by the soils of the bottom lands at times of overflow, lost by evaporation, and diverted for irrigation and other purposes.

cropped lands of that part of the watershed lying between the High Plains and the Coast Prairie. The total cropped land thus included is 6,748,324 acres. The loss of soil from the cultivated land, thus calculated, would therefore amount to approximately 12.4 tons an acre a year, due to sheet erosion alone (fig. 30). When water accumulates in gullies, its cutting and carrying power is greatly amplified, so that tremendous amounts of soil are lost in this manner. No data have been obtained as to the exact amount of such losses, but where land is badly gullied the soil losses will probably range at least from 20 to 30 percent greater than where only sheet erosion is taking place. However, calculations based upon losses caused by sheet erosion alone show that an average of approximately one twelfth inch of soil a year is being lost from the cultivated lands of the watershed, excluding the High Plains and the Coastal Prairie. In other words, under average conditions it requires only about 48 years to remove the soil to a depth of 4 inches, the average plow depth of the region. On hilltops and the steeper slopes erosion is much more severe and it

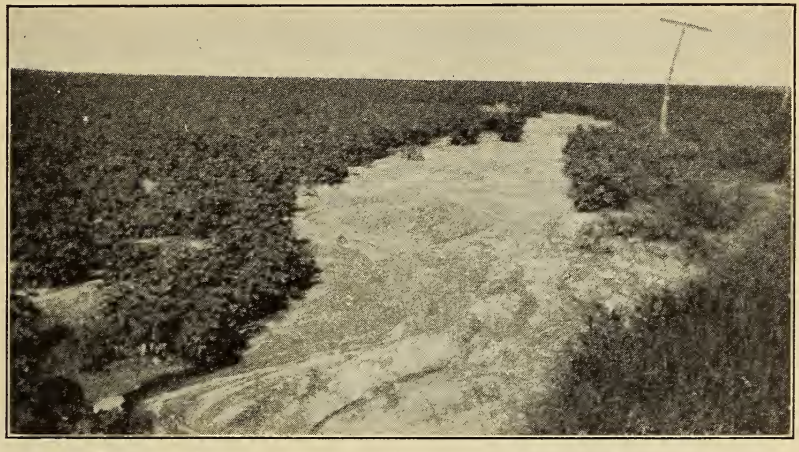


FIGURE 30.—Tremendous amount of washing by a single rain on Houston black clay in September 1932. Hundreds of tons of soil were washed from this field in a few hours.

is not uncommon to find areas from which 3 feet or more of soil have been carried away by sheet erosion. It is futile to attempt to improve the fertility of sloping land so long as the topsoil and all it contains is allowed to wash away continuously and at an astoundingly rapid rate.

IMPORTANCE OF WATER CONSERVATION

Contouring, terracing, the growing of cover crops, strip cropping, incorporation of manure and humus in the soil, and other such practices, besides saving soil, all slow down the movement of run-off rain water, causing more of it to sink into the soil. During dry seasons the extra water saved in this way is often sufficient to make a good crop, where otherwise the crop might have been a failure. Many farmers report that the increase in yield the first year, from the saving of moisture, has been more than enough to pay for the cost of terracing. At the Texas Agricultural Experiment Substation at Spur, in west Texas, where the rainfall is sometimes deficient during

the growing season, it has been found profitable to divert run-off water from pastures and roadways onto terraced or diked land so as to cause increased storage of water in the soil. This has greatly increased the yields. It is believed now by some authorities that a similar conservation of soil moisture would prove valuable in the humid region of Texas, where summer droughts occasionally cause losses in crop production.

NEED FOR IMMEDIATE PROTECTION OF LAND

In the Brazos watershed the amount of cultivated land amounts to nearly 9½ million acres. Of this, more than 6¼ million acres are being gradually denuded by sheet erosion. This type of land is usually gently sloping, and as yet has not started to gully. It is a comparatively simple operation to build terraces on such land, and the cost is not high. On the gentler slopes, planting strips of oats, cane, or other erosion-resisting crops, along the contours, alternating with strips of such clean-tilled crops as cotton and corn, would give the land a high degree of protection.[14] At least it would greatly minimize erosional

FIGURE 31.—This field of Sumter clay, once fertile black land, is so badly gullied that it is now almost impossible to operate farm machinery on it. Between the gullies the surface soil is almost entirely gone. Near Rogers, Tex.

damage until such time as terraces could be constructed. If the strips of feed crops or other thick-growing crops are made sufficiently wide, and are located along prospective terrace lines, terraces may be built on these strips during the summer without damaging the crop planted between the strips.

Nearly 2 million acres, or approximately 20 percent of the cultivated land in the watershed is already gullied, and the amount is increasing rapidly. Moreover, most of the gullies which already exist, are cutting deeper and becoming wider every year. They are also extending farther up the slopes and are sending out innumerable lateral branches. Gullied land is more difficult and expensive to terrace than land which is only affected by sheet erosion. The land must be saved. The sooner it is given protection, the cheaper and simpler this will be, and the greater the amount of fertility the soil will still possess (fig. 31).

[14] GEIB, H. V. STRIP CROPPING TO PREVENT EROSION. U.S. Dept. Agr. Leaflet 85, 6 p., illus. 1931.

All too often land that is not gullied is thought of as being free from erosion. The results obtained from the various erosion stations, however, have brought out the costly effects of sheet washing which goes on regardless of gullying. Even where land is absolutely level the soil losses have been significant. The greater the slope, the greater the degree of erosion for most soils.

OTHER SERIOUS LOSSES

While the greatest loss caused by run-off rain water is from stripping off land by sheet erosion, and the formation of gullies, there are other losses which at times are enormous. During wet seasons the flooding of stream valleys often causes losses to crops amounting to millions of dollars.[15] Fertile bottom lands are sometimes covered with heavy deposits of sand, rendering them almost worthless. Farm buildings are often destroyed by flood water, and human lives are frequently lost. Silting of reservoirs takes place with exceeding rapidity, thus entailing tremendous expense in cleaning or rebuilding these reservoirs. Additional damage to highways, railways, and many private and public enterprises amounts to thousands of dollars annually.

RESERVOIRS

It has been proposed that a dozen or more large storage dams be constructed at strategic points along the course of the Brazos River and its principal tributaries.[16] These would be used to impound excess run-off water for the purpose of minimizing danger of floods. Such impounded water, according to the plans proposed, would be utilized for irrigation and power purposes, thus earning the cost and operating expenses of the impounding system. Should this plan be put into operation it would be vitally necessary that all of the badly eroding land from which water drains to any reservoir be terraced or given other protection, in order to reduce silting of the storage basins. Otherwise, reservoirs built to hold water will have their capacity continuously reduced by filling in with soil, thus entirely defeating the purposes of construction, as has already happened in numerous instances.

SUMMARY

Years ago, before man began the breaking down of nature's stabilizers by plowing up the turf of the prairies and plains, and cutting off and burning over the timber lands, it is claimed that the devastating floods now so common within the Brazos watershed, did not occur with present-day violence.

More educational work is necessary among the farmers, absentee landowners, and the public in general, to bring about a greater consciousness of the necessity for prompt action if the agricultural industry is to be saved from complete collapse on millions of acres of rolling lands throughout the Nation. Although much valuable work has been done in connection with the erosion problem, there remains to be carried out much more experimental investigation in order to determine the most effective and practicable means of lessening

[15] WEST, G. R. PRELIMINARY REPORT UPON BRAZOS RIVER CONSERVATION AND RECLAMATION DISTRICT, STATE OF TEXAS. Reclamation Dept., Missouri Pacific Railway Lines, St. Louis, Mo. November 1929.

[16] See footnote 15, *supra*.

erosional damage, of remedying the damage already done, and of rebuilding the impoverished soil and restoring to it a fair degree of fertility.

It is self-evident that all practicable means should be made use of without delay in order to save what soil still remains, that a foundation may be had upon which to rebuild a profitable and permanent agriculture.

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